MEMOIRS

OF THE

CARNEGIE MUSEUM.

Vol. VII. No. 6.

THE AMERICAN DICERATHERES.

By O. A. Peterson.

(Plates LVII–LXVI.)

Introductory.

At the outset the writer wishes to acknowledge his indebtedness to Dr. W. J. Holland for much valuable assistance and advice in the preparation of the following paper, and for permission freely to use the material in the Carnegie Museum. To the authorities of the Peabody Museum of Natural History at Yale University thanks are due for their courtesy in allowing me to study and illustrate the types of Professor O. C. Marsh. I wish to express my gratitude to Professor F. B. Loomis, of Amherst, for granting me free access to his collection of types and drawings. I wish to gratefully acknowledge the kindness of the authorities of the American Museum of Natural History for granting me the privilege of examining the material from the John Day beds forming a part of the collection of the late Professor Cope, and allowing me to describe a new species of the genus *Diceratherium*. Thanks are also due to the Librarian of Congress for literature forwarded for consultation to the Carnegie Museum, to Mr. James W. Gidley, of the U. S. National Museum, and to Mr. Harold J. Cook for information. Mr. Syndey Prentice has carefully executed the drawings here reproduced.

Earlier Investigations.

A number of papers dealing with the subject of this memoir have from time to time appeared, based upon material obtained by different parties, who in the past two decades have worked in western Nebraska and contiguous territory. Some of these papers possess genuine value. Other papers have also appeared, which indicate that the study given by their authors was hasty and of only a preliminary nature, often containing mistakes, which cause more or less difficulty to the student. One marked error has been the attribution of specific value to certain characters of the dentition and other parts, which after a more exhaustive study are clearly seen to be misleading. It is hoped that the following pages may prove to be a stimulus to further study and the exercise of greater care in this field of investigation.

In earlier contributions relating to the Diceratheres published by the author it has been stated that a more detailed study of the large collection obtained in the Agate Spring Fossil Quarries would be forthcoming, after the process of extracting the fossils from the matrix should be completed. Since that announcement much work has been done. The writer having at his command material consisting of the remains of some two hundred or more individuals, was induced to question the validity of some alleged specific characters. It is hoped that the following pages may supply safeguards against error in the future. With only a few specimens before him, a student may establish species to his own satisfaction upon characters selected by him at the time, but which after more abundant material is accessible to him may prove to be invalid.

In various publications[1], there have been reported to be in the Agate Spring Fossil Quarries and their immediate neighborhood no less than seven species of the genus *Diceratherium*, besides a new genus, *Metacœnopus*. At first glance it might appear that the characters relied upon by the authors in establishing the different forms are valid, but after a more intensive study it is found that some species must be abandoned, and others must be regarded as doubtful. The result of our recent investigations proves that in this case we must either condense the number of proposed species, or establish an infinite number of additional new forms. The latter course would be eminently unscientific, though justifiable if we accept as valid the characters employed and relied upon in discriminating the various

[1] Loomis, F. B., Amer. Jour. Sci., Vol. XXVI, 1908, p. 51–64. Cook, Harold J., Amer. Naturalist, Vol. XLII, 1908, p. 543–545; Nebraska Geol. Surv., Vol. III, 1908, p. 245–247. Barbour, E. H., Science, N. S., Vol. XXIV, Dec. 14, 1906, p. 780–781. Peterson, O. A., Science, N. S., Vol. XXIV, Aug. 31, 1906, p. 282–283.

species which have been proposed. Whether the views expressed in the work upon the Diceratheres here offered shall prove to be conclusive, can only be ascertained in the light of the future. The improbability of having been able to reach an absolutely final conclusion is abundantly realized by the writer.

Stratigraphy.

Since the earliest descriptions of the European forms of the Diceratheres by Pomel (1853), Duvernoy (1854), and the final determination of the genus by Marsh (1875), many papers treating of the Rhinocerotidæ have appeared in America as well as in the Old World. Through the studies of Professor Osborn and Mr. Hatcher, based upon some early American forms, we learn that the phylum *Diceratherinæ* had already acquired incipient nasal horns in the White River Oligocene of South Dakota. It is now known that the forms, not alone of *Diceratherium* from the succeeding John Day beds, but all other mammalian remains available for comparison from the same horizon of the John Day in which *Diceratherium* is found, represent an earlier facies than those from the Nebraska-Dakota Miocene.

In order to give conveniently a clear view of the stratigraphic correlation the diagram on page 402 is inserted.

The Oligocene in South Dakota, as is well known, is much more extensively developed than in Nebraska. It comprises, besides the three usually recognized faunal zones, the Titanotherium beds (= Chadron beds), the Oreodon, and the Leptauchenia beds (= Brulé beds), two other easily recognized divisions, one the Metamynodon beds included in the Brulé beds, and the other, the Protoceras ERRATA- sandstones, ~~both~~ in the Leptauchenia clays both of which arose from deposits made by streams. The Miocene section of South Dakota falls into two (Lower and Upper Rosebud beds), instead of the four divisions, recognized in Nebraska. The four divisions of the Nebraska Miocene comprise the Gering, the Monroe Creek, the Lower and the Upper Harrison. The latter is regarded by the writer as the base of the Middle Miocene. The lower portion of the John Day beds may be regarded as of transitional character and should therefore be classed as either uppermost Oligocene or lowermost Miocene, the only difference being that they are not separated from the Middle John Day beds by any apparent stratigraphic break. The Mascall beds of the John Day are somewhat later than the Upper Harrison beds of Nebraska, as indicated by a comparison of the faunæ.

We know the earlier progenitors of *Diceratherium* less clearly, though it is held that *Cœnopus occidentalis* (Leidy) from the middle Oligocene and *Cœnopus*

	South Dakota.		Nebraska.		John Day.		European.	
PLIOCENE.			*Snake River Beds.* Sand and soft sandstones, thinly bedded.		Rattlesnake Formation.			
MIOCENE.	*Upper Rosebud.* Soft sandstone and sandy clays.		*Upper Harrison* Massive soft sandstone.	Base of Middle Miocene	*Mascall.* Tuffs, ashes, etc.		Upper and Middle Miocene.	
			Lower Harrison. Interstratified with harder sandstone ledges.	*Diceratherium cooki; D. niobrarense.*	*Columbia.* Lava, basalt, and tuffs.			
	Lower Rosebud. Soft sandstone and sandy clays.	*Diceratherium gregorii* sp. nov.	*Monroe Creek Beds.* Hard sandstone.		*Upper John Day*		Lower Miocene (Aquitanian).	
			Gering. Soft sandstones and sandy clays.	*Dicerather.* sp.	Middle and Lower John Day.	*D. annectens; D. armatum.*		*Diceratherium pleuroceros.*
OLIGOCENE.	*Upper Brulé* Leptauchenia clay and Protoceras sandstones.	*Cœnopus tridactylus; C. dakotensis* sp. nov.	*Upper Brulé.* Leptauchenia clay.		Lower John Day transitional from Miocene to Oligocene.	*Rhinoceroses,* spp. ind.	Upper Oligocene (Stampian)	
	Lower Brulé. Heavy bedded clays, Metamynodon sandstones.	*Cœnopus occidentalis; C. copei.*	*Lower Brulé.* Clays and thin sandstone ledges.					*Protaceratherium (Diceratherium) minutum.*
	Chadron. Clay and sandstones, Titanotherium Beds.		*Chadron.* Clays and sandstones. Titanotherium Beds.				Lower Oligocene (Sannoisian).	

copei (Osborn) from the lower Oligocene (Metamydon beds) may be looked upon as at least in the line of this family.[2]

While the general trend of the characters of *Cœnopus tridactylus* and *Cœnopus dakotensis* sp. nov. is obviously in the direction of *Diceratherium,* it is in the John Day that we first recognize the genus as occurring in America. The South Dakotan and especially the Nebraskan series of Diceratheres are a later group belonging to the lower Miocene, closely following the species of the John Day, while the so-called *R. oregonensis* Marsh is an inadequate type, which furnishes information altogether too meager to be assigned to *Diceratherium* as is done by Pro-

[2] Osborn, H. F., Mem. Amer. Mus., Vol. 1, 1898, p. 164.

fessor Loomis. Among Professor Osborn's third phylum of the later Miocene Rhinoceroses[3] we may find a representative of this phylum.

In Europe *Diceratherium pleuroceros* (Duvernoy) is the most completely preserved type from the Aquitanian. Its geological horizon apparently approximates in age the John Day beds of North America.

From the cast of this European species (Fig. 1) it is seen that the cranium back of the orbit is very suggestive of *D. annectens*. The brain-case has similar small

FIG. 1. *Diceratherium pleuroceros* (Duvernoy). From a plaster replica in the Carnegie Museum. × 1/6.

proportions, the supra-orbital ridges converge gently to form a similarly short sagittal crest, though less prominent and more rounded in the European form. The inion is also somewhat higher in the latter. The muzzle is long, though higher, and perhaps having more the proportions of that part in *D. niobrarense* from the Nebraska Miocene. The basi-cranium in the cast of *D. pleuroceros* is short and the mastoid process is in touch with the post-glenoid process. Thus the contour of the skull of the European species apparently has combined characters of *D. annectens* from the John Day and of *D. niobrarense* from the Nebraska Miocene. The dentition of the European form is too much worn to allow accurate comparison. By regarding such forms as *Protaceratherium*[4] ("*Diceratherium*") *minutum* (Cuvier) of the Stampian as approximately parallel to *Cœnopus* of the upper and middle Oligocene of North America, it appears that the family may be traced back to nearly the same geologic time in Europe and North America,[5]

[3] Bull. Amer. Mus., Vol. XX, 1904, p. 321; *Aphelops (?Peraceras) planiceps*, p. 322; *Aphelops (?Diceratherium) brachyodus* p. 324.

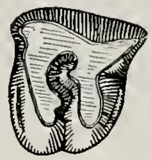
[4] Abel, O., "Kritische Untersuchungen über die paläogenen Rhinocerotiden Europas," Abh. der K. K. Geologischen Reichsanstalt, Band XX, Heft 3, 1910, p. 10.

[5] Osborn, Henry F., "Phylogeny of Rhinoceroses of Europe," Bull. Amer. Mus. Nat. Hist., Vol. XIII, 1900, p. 229–267; "Age of Mammals," p. 90.

while according to recent work by European authors *Prohyracodon orientale* Koch is regarded as the earliest and most primitive representative of the Rhinocerotidæ.[6]

Diceratherium armatum of the John Day formation has the dentition as well as certain other features of the skull in a much less advanced stage of development

2



3

Fig. 2. *Diceratherium minutum* (Cuvier). $M^2 \times \frac{1}{2}$. After Cuvier.
Fig. 3. *Diceratherium douvillei.* $M^2 \times \frac{1}{2}$. After Osborn.

than *D. annectens* of the same deposit (Compare Pl. LVII with text-figure 11, also with Pl. LXIII, fig. 6, and Pl. LXVI, fig. 1). In the latter form we naturally might expect to meet with a greater range of anatomical variations, especially in connection with the dentition. We may reasonably expect to find grinding teeth, having crests ranging from those which are quite plain to those which have the various incipient projections, as crista, crochet, anti-crochet, etc. It is far from my mind to depreciate some, or all, of these characters; on the contrary, indeed, it is reasonable to expect that the dentition should be one of the first parts of the organism to undergo modification with a change in the environment. It is nevertheless questionable whether the absence or presence of a crista, a crochet, and anti-crochet, more or less developed, or of a cingulum of greater or less prominence, should constitute a valid specific character in *Diceratherium.* I very much doubt whether these characters are of sufficient constancy to be relied upon to establish specific distinctions in a large collection of individuals from a given locality. Stress has in times past been laid upon the development of branches or spurs of different lobes of the cheek-teeth. It is plainly evident that *D. annectens,* as the result of its mode of life, was already in the time of the John Day more advanced, having filled out the grinding surface of its teeth more than its contemporary, *D. armatum.* In animals representing a later development in geological time, we should expect to find similar evidence of progression, and in a large assemblage of individuals that not all the specimens, say of *D. cooki* for example, are provided with crista and crochet united on the premolars and with crista small and crochet larger on the molars, but that these features, being in a plastic stage of development, *would be found in an endless number of combinations from those less developed to those having more complex forms, and all within one species.*

[6] Abel, O., *l.c.*, p. 24, 44–45, 49.

Another feature, which often has been misinterpreted in connection with the study of the Diceratheres, is the difference in the contour of the skulls. It is a well-known fact that in individuals of almost any group of mammals the contour of the skull changes until well after complete maturity. Furthermore the sexual differences in the form of the skull in the *Diceratherine* branch of the Rhinocerotidæ are surprising. In the early development of the phylum the difference between the sexes was well indicated by the form of the skull.[7] This is undoubtedly due in great measure to the possession of the prominent nasal horns by the male. In a young male, for instance of *D. cooki*, there are found the incipient horn-cores, the nasals are quite long and pointed in front of the horns, while back of the horns there is relatively small lateral constriction of the nasals, the temporal ridges are generally weak and not united to form a sagittal crest, the zygomatic arches are slender, often without, or with very slight, rugosities on the posterior angles. This is also quite generally true of the skull of an adult female, with the exception that in the latter there is a gradation from skulls without any horn-cores in the young, to those having incipient horn-cores in some of the fully adult and old, and that there is considerable variation in the prominence of the temporal ridges and the manner of their convergence before they reach the inion. I have as yet never seen a well-developed and heavy horn-core, the ends of the nasals short and blunt, the skull much constricted laterally back of the horn-cores, saddle-shaped on top, with a sudden lateral expansion and heavy rugosities on the posterior angles of the zygomatic arches in *D. cooki*, except in association with well-worn or very old dentitions. It is very plain to me that more latitude should be assigned to the significance of the contour of the skull in the genus *Diceratherium* than has sometimes been done. In study and comparison especial pains should be taken (1) to ascertain whether the skull is that of a male or a female, or of the young, or not entirely adult animal; (2) skulls of fully adult or old males are more uniform in contour than any others, and therefore more reliable in establishing species; (3) the significance of the crushing received by the specimen in one direction or the other should be noted.

The following table of comparisons represents fairly well the large number of skulls of *Diceratherium cooki* in the collection of the Carnegie Museum. Remains of very young animals are not included in this table, but will be treated separately. The object of the descriptions given under H, Nos. 2816, 2463, and 2478 in the following table are to draw attention to the great ease by which misinterpretations may result with only a portion of the skull in hand and displaying characters, some of which may be only pathological.

[7] Osborn, Henry F., "The Extinct Rhinoceroses," Mem. Am. Mus. Nat. Hist., Vol. I, Part III, 1898, p. 162.

Contour of Skull compared with the Dentition.

	Contour of Skull.	Dentition.
A. No. 1572. Type of *D. cooki*. Old male.	Skull symmetrical in the region of the parietals, occiput, zygomatic arches, and palatal regions, but very slightly depressed by crushing in the frontal and nasal regions. Horn-cores prominent, nasals blunt and constricted back of horns, frontal region broad and flat, temporal ridges moderately prominent, but not united to form a sagittal crest, brain-case broad, arches suddenly expanded posteriorly, heavy and rugose on posterior angle. Skull comparatively broad and low.	Dentition considerably worn. Crista of premolars worn off, median valley on P^2 and P^3 isolated by wear, crochet of P^2 and P^3 united with ectoloph, cingulum on P^2 quite strong, crochet on P^4 not entirely united with ectoloph; crochet united with ectoloph, median valley open and post-fossette isolated on M^1; crista slight, crochet heavy, and post-fossette open posteriorly on M^2; crista weak and crochet strong on M^3.
B. No. 1841. Paratype of *D. cooki*. Young male.	Skull somewhat distorted by crushing and otherwise unreliable on account of immature age. Horn-cores incipient, nasals pointed, not projecting over the premaxillaries, due partly to crushing, a considerable constriction of nasals back of horn-cores; frontals comparatively narrow and slightly convex from side to side, due partly to crushing and partly to immaturity. Temporal ridges less prominent and not united to form a sagittal crest, but quite broadly united with the occiput, brain case broad, zygomatic arches expanded posteriorly and plainly indicating the usual rugosities formed in mature males. Skull comparatively narrow, partly due to immaturity and partly to crushing.	Permanent incisors just appearing in the alveoli of the premaxillaries. P^1 considerably worn, causing the post-fossette to have already become isolated. P^2 very slightly worn, crista and crochet very slightly developed and not united on tooth of the right side, while that on the left side has crista and crochet better developed and would on much wear form an isolated medifossette; anticrochet slightly indicated. P^3 has crista and crochet quite well developed and united. P^4 is well worn, has a small tubercle in the median valley between proto-and metalophs, crochet well developed, nearly meeting the crista, which is only slightly indicated on the tooth of the right side. M^1 with well developed crista and crochet nearly meeting to isolate the medifossette. M^2 just erupted, and shows even less development of crista, but with strong crochet. M^3 buried in the maxillary.
C. No. 1923. Young male.	Top of skull more symmetrical than in No. 1841, but considerable lateral crushing has taken place, especially noticeable in the region of the palatines. Base of skull open at suture and basioccipital lost. Horn-cores incipient, nasals projecting over the premaxillaries, more than in some specimens, slightly less pointed anteriorly and more constricted back of the horns than in No. 1841; frontals convex from side to side and proportionally narrow, due to crushing and immaturity; temporal ridges quite weak especially on right side, not united to form a sagittal crest; brain-case wide, zygomatic arches heavy, indidicating that on further development of the skull the rugosities on posterior angle would be heavy as in old males generally. Skull comparatively narrow and high.	P^1 in same stage of wear as in No. 1841, P^2 quite simple, no crista, a weak crochet, which on further wear of the tooth would practically disappear; post-fossette very large. P^3 not as yet worn, both crista and crochet weak, but showing a tendency to unite so as to isolate the medifossette on further wear of the tooth; post-fossette broadly open posteriorly. $D.P^4$ much worn, median valley nearly isolated by wear of proto- and metalophs; a tubercle of small size in the median valley; post-fossette isolated. M^1 with double, though small, crista; crochet heavy nearly reaching the protoloph; post-fossette broadly open posteriorly. M^2 just starting to receive wear, crista extremely weak, crochet stronger than usual. M^3 buried in the maxillary.

CONTOUR OF SKULL COMPARED WITH THE DENTITION.—*Continued.*

	Contour of Skull.	Dentition.
D. No. 2467. Fully adult female.	Skull somewhat crushed backward and to one side, though of quite symmetrical appearance. Only a suggestion of horn-cores, nasals not projecting over the premaxillaries, quite long and pointed in front of the horn-cores and very little constricted back of them; frontals quite broad, though slightly injured by lateral crushing; temporal ridges prominent, and remaining well apart throughout to the occipital crest; brain-case large, zygomatic arches light. Skull proportionally high and narrow.	Small functionless and persistent canines indicated on both sides. P^1 much worn. P^2 with no crista, but a weak crochet, the latter being double on tooth of left side; a small antecrochet present on this tooth of the right and left jaws and the post-fossette nearly enclosed. P^3 without crista, crochet also poorly developed, crenulated, and post-fossettes isolated by wear. P^4 with weak crista and crochet. All the premolars with strong cingulum internally. M^1 with no crista, but heavy crochet, a minute tubercle in the median valley; a large post-fossette and no cingulum on internal face of the tooth. M^2 with weak crista but strong crochet, a very minute tubercle in the median valley, post-fossette broadly open and cingulum only faintly indicated on the internal faces of the tooth. M^3 has received little or no wear. Crista and crochet very poorly developed.
E. No. 1855. Paratype of *D. cooki.* Female.	Skull somewhat crushed to one side. Nasals broken well back, but the sides do not indicate as great a constriction as in skulls of males. Frontals broad; temporal ridges quite prominent and placed quite close together before reaching the inion, but not forming a sagittal crest. Brain-case broad, zygomatic arches light. Skull rather broad and low, to a great extent brought about by crushing.	P^1 much worn. P^2 with medi- and prefossettes quite distinct; crochet with crenulated border, post-fossette large. P^3 quite worn, but medifossette indicated. Crochet nearly united with ectoloph. Post-fossettes quite large. P^4 with medifossette (especially on the tooth of right side) isolated, prefossette and median valley united. Post-fossette large. Premolars with heavy cingulum. M^1 much worn, no crista, crochet nearly united with ectoloph; post-fossette large, cingulum weak. M^2 with strong crista and crochet (the two nearly meeting on tooth of right side). Post-fossette large. M^3 with crista and crochet much better developed on tooth of left side, cingulum weak on molars.
F. No. 2809. Male.	Skull slightly depressed by crushing. Nasal horn-cores very robust, nasals extend in front of premaxillaries, bluntly pointed anteriorly and gently constricted back of horn-cores; frontals broad; temporal ridges prominent and remaining far apart all the way back to the occiput. Brain-case large; zygomatic arches very robust on the posterior angle. Skull rather low and broad.	Dentition represented only by P^3 and P^4 and M^1 and M^2. P^3 with no crista; crochet strong, crenulated internally and nearly united with ectoloph. Post-fossette large. P^4 with no crista, crochet strong an crenulated, as on tooth in advance of it. Post-fossette large. M^1 with no crista, but strong crochet, which on a little further wear would unite with the ectoloph. Post-fossette nearly isolated by wear. M^2 with prominent crista and crochet. A tendency to develop a small tubercle in the median valley. Post-fossette large. The premolars have cingulum better developed than on the molars.

Contour of Skull compared with the Dentition—*Continued.*

	Contour of Skull.	Dentition.
G. No. 2408. Paratype of *D. cooki.* Rather young female.	Skull somewhat depressed by crushing, especially over the posterior part of the nasals and the frontals. Nasals not projected in front of the premaxillaries, pointed, no horn-cores indicated, but nasals thickened in this region; little or no constriction back of the thickened region; frontals broad and flat; temporal ridges fairly prominent and early united to form a sagittal crest before the inion is reached (the latter is broken off); brain-case broad; zygomatic arches slender. Skull proportionally broad and low, due partly to crushing.	Dentition comparatively little worn. P^1 well worn. P^2 with medifossette isolated, especially on tooth of right side, tiny crenulation on the face of the crochet wall, post-fossette widely open behind. P^3 with medifossette isolated, crenulation on crochet as on preceding tooth, post-fossette large. P^4 with medifossette isolated, especially on tooth of left side, post-fossette large; prominent cingulum on internal faces of premolars. M^1 with moderate rounded crista and heavy crochet, but not united to form a closed medifossette, post-fossette broadly open posteriorly. M^2 with more prominent crista, which very nearly unites with the crochet, post-fossette large. M^3 well erupted, but not yet in contact with the lower teeth, crista and crochet rather delicately developed. Cingulum little developed on the internal faces of the molars.
H. No. 2463. Old female with pathological deformity.	Skull crushed so as to produce an unusually, high occiput. Frontal and nasal regions quite symmetrical. Anterior portion of nasals and premaxillæ broken off. Anterior portion of skull not unlike that of No. 1572 (type of *D. cooki*) in fact the general contour is similar. However, the sagittal region is narrower, there being a decided sagittal crest in the present specimen. Zygoma lighter, without the rugose area on the posterior angle. The comparatively light structure of the skull clearly indicates a female specimen.	P^3 of left side represented only by an extremely thin band of dentine. P^2 and M^1 closely succeeding one another, nearly closing up the space for P^4. This was accomplished during the life of the animal. M^3 of both sides have curious metastyles located on the postero-internal angle, a deep fissure separating them from the main body of the teeth; median valley open, but crista and crochet well shown. Dentition much worn (See Fig. 4.)
No. 2816, Male. No. 2478, Male?	The greater portion of skull No. 2816 is preserved, while No. 2478 is only represented by a portion of the top and back. These two specimens are no less unique than No. 2463 just described. The chief feature is the inflated condition of the frontals, which is not unlike that in *Rhinoceros bicornis,* except that in the fossil specimens the swollen area is confined more to the posterior portion of the frontals. In No. 2478 the inflated area is more pronounced than in 2816 and also differs in the median line from the latter, having this inflated region continued backward as a prominent rounded ridge between the temporal ridges. Judging from the heavy and rugose zygomatic arches on No. 2816 the skull is undoubtedly that of a male.	The dentition of No. 2816 is essentially that of *D. cooki,* while in No. 2478 there are no teeth represented.

In comparing (*D*) No. 2467 in the above table with the description by Dr. Loomis of his proposed species *Diceratherium schiffi* it will at once be observed that while the general contour of the skull agrees fairly well, the dentition totally disagrees in the presence of the minute canines[8] and the difference of the configuration of the grinding surfaces of the teeth. We are not permitted, therefore, according to the usually accepted view to refer this specimen to the above proposed species. The same comparison with (*G*) No. 2408 shows that while the dentition agrees, the contour of the skull is less in accordance with the above-mentioned description, and corresponds better with the original type of *D. cooki*, sexual characters excepted. With another female skull (*E*) No. 1855, one of the original specimens used as a paratype in my earliest paper, *D. schiffi* seems to agree best, except that the temporal ridges come closer together before reaching the inion. It is thus seen that in comparing female skulls it is frequently found that dentition and contour of skull do not both agree; on the contrary the material affords numerous different combinations. There are of course female skulls which occasionally answer to the description by Loomis somewhat more closely than in the cases stated above. However, it is quite obvious that we would create a difficult task for the systematist and student, not to say a non-scientific record of the subject, were we to establish additional species founded upon our abundant material. The different patterns of the premolar and molar teeth which were formerly regarded as satisfactory for the establishment of species are obviously not to be relied upon, at least not in connection with the study of the material from the Agate Spring Fossil Quarries. The differences to which allusion is here

FIG. 4. Upper dentition of *Diceratherium cooki*, C. M., No. 2463, showing the reduced condition of P^4 of right side and accessory tubercles on M^3. $\times \frac{1}{2}$.

[8] The canines are probably deciduous teeth, which sometimes abnormally persist and their presence may be regarded as only an individual peculiarity. Professor Owen speaks of a canine in the fœtal skull of *Rhinoceros indicus* ("Odontography," p. 592).

made should rather be regarded as in the main due to the varying extent to which specialization has operated in the individual. The teeth, especially of the smaller American species of the Diceratheres of the Nebraskan Miocene, may be said to be in a stage of rather rapid and progressive change. It is hardly probable that we shall be able to perfect any satisfactory adaptive radiation of forms, such as has recently been suggested,[9] from the study of this material. In paleontology we are debarred from the finer subdivisions used in recent zoölogy. We have to content ourselves with characters which stand out more prominently and which may be used not only to clearly determine species, but to give aid in the question of correlations of faunæ and demarcations in geology. From the study of the collection above tabulated, we are forced to regard the variations shown as being individual, sexual, juvenile, and pathological.

1. **Rhinoceros** (?**Diceratherium**) **pacificus** Leidy,[10] *incertæ sedis.*

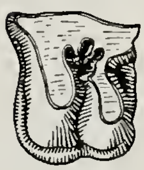


Fig. 5. *Diceratherium pacificum* Leidy, M^2. × ½. After Leidy.

Type.—Upper molar, left side. United States National Museum.

Horizon.—? Miocene.

Locality.—"Alkali Flat" John Day region, Oregon.

Paratype.—A mutilated fragment of the upper jaw of the right side, with portions of the fangs of the true molars and an inferior molar tooth.

Horizon.—? Miocene.

Locality.—Bridge Creek, John Day region, Oregon.

As indicated in Leidy's original description this material from "Alkali Flat" in the John Day region, Oregon, was provisionally referred to *Cœnopus* (*R.*) *occidentalis.* Receiving more material from the same general region Leidy again restudied the "Alkali Flat" specimens and finally placed them, together with the material from Bridge Creek, under his species *R. pacificus.*

This type like that of the John Day material referred to as *R. hesperius* we now find to be inadequate, or of very doubtful generic value. Leidy was apparently not clear as to the true association of these different fragments and teeth. On page 222 (*l.c.*) he states that the second molar described, "may be a true molar of the preceding species" [*R. hesperius*] described in his report.

I am unable to agree with Dr. Loomis in accepting this species as valid and am obliged, as the result of the study I have made, to regard this type as *incertæ*

[9] Loomis, F. B., *l.c.*, p. 53.

[10] Proc. Acad. Nat. Sci., Philadelphia, 1870, p. 112; 1871, p. 248; U.S.G.S. Terr., Vol. I, 1873, p. 221. Plates II, VII, Figs. 6–7, 24–25; Amer. Jour. Sci., Vol. XXVI, 1908, p. 55–56, Fig. 6.

sedis. It pertains to an animal no larger than, for instance, *D. annectens* (Marsh), but that is about all I feel justified in positively stating.

2. **Rhinoceros** (?**Diceratherium**) **hesperius** Leidy,[11] *incertæ sedis.*

Type.—A third upper molar. Location of the type uncertain.

Horizon.—Miocene?

Locality.—John Day region, Oregon.

The material from the John Day of Oregon, which Leidy finally referred with a question to the Californian species "*Rhinoceros hesperius,*"[12] is, as Leidy himself states, inadequate. The more important features of the remains of the skull appear to be the position and size of the infra-orbital foramen and the position of the base of the zygomatic process of the jugal. Of material referred to *R. hesperius* Leidy says (*l.c.*, U. S. G. S., Vol. 1, p. 220): "The anterior extremity of the space included by the zygoma extends to a line with the interval of the second and third molars; in *Rhinoceros* [*Cœnopus*] *occidentalis* it extends only to a line with the back part of the last molar. The infra-orbital foramen is large and occupies a position above the second premolar; in *R.* [*C.*] *occidentalis* it is over the third premolar." This description agrees with *D. cooki* so far as the zygomatic arch is concerned, but the infra-orbital foramen of the latter species is usually opposite the interval between P^2 and P^3 both in *D. annectens* and *D. cooki.* In *D. annectens* the space included by the zygoma referred to by Leidy is slightly more posterior. In comparing the measurements of well-known species of *Diceratherium* with the figures of specimens referred to *R. hesperius* and *R. pacificus* it is seen that M^3 of *hesperius* might well go with the molar of *pacificus.* So far as the difference in size and even the configurations of the crowns in these teeth go, there is now no valid reason for separating the two on the evidence produced. The tubercle of the median valley of M^3 of *R. hesperius* may well be questioned as a specific character, and is in all probability, as Leidy suggests, "merely an individual peculiarity." In my opinion these remains are generically and specifically unidentifiable, but hold the historic position of being the first material of the Rhinocerotidæ obtained in the John Day region of Oregon.

FIG. 6. *Diceratherium hesperium.* (Leidy) M^3. $\times \frac{1}{2}$. After Leidy.

[11] Proc. Acad. Nat. Sci. Phila., 1865, p. 176–177; 1870, p. 112; 1871, p. 248. U. S. Geol. Surv. Terr., Vol. I, 1873, p. 220, Pl. II, Figs. 8–9. Amer. Jour. Sci., Vol. XXVI, 1908, p. 55, Fig. 5.

[12] Professor Osborn has placed this Californian specimen with *Cœnopus platycephalus,* "The Extinct Rhinoceroses," Mem. Amer. Mus., Vol. I, 1898, p. 144.

3. **Rhinoceros** (?**Diceratherium**) **oregonensis** Marsh,[13] *incertæ sedis.*

Type.—Penultimate upper molar. Peabody Museum of Natural History No. 10,002.

Horizon.—("Pliocene deposits of Oregon") Mascal formation.

Locality.—John Day region, Oregon.

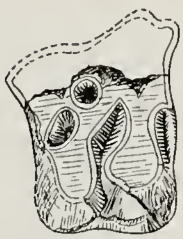


FIG. 7. (?*Diceratherium*) *Rhinoceros oregonensis* Marsh. M^2. × ½. After Loomis.

In reference to this fragment Marsh says: '. . . At the union of the transverse posterior ridge with the outer cusp, there is a deep cavity, nearly circular, and enclosed by a vertical cylinder of enamel. The anterior crest, also, is divided, a strong branch being sent inward and backward from the posterior side into the main transverse valley."

Whether or not this specimen pertains to a Dicerathere may never be settled. I have recently examined this tooth and may state that it may equally well belong to a middle Miocene Rhinoceros (Teleoceras). I cannot now see any reason for regarding this type as anything except of indeterminate value.

4. **Diceratherium** (?) **truquianum** (Cope), *incertæ sedis.*

Type.—A symphysis of the lower jaws with all the incisors and the posterior portion of the ramus with M_2 and M_3. American Museum Natural History (Cope Collection) No. 7333.

Horizon.—Lower John Day, Miocene(?).

FIG. 8. *Diceratherium truquianum* (Cope). No. 7333, Coll. Am. Mus. Symphysis and portion of left ramus. × ¼.

In describing an incomplete mandible from the ("Truckee beds"[14]) (Lower John Day) Professor Cope says that the specimen "supports molar, canine [= lateral incisor], and incisor teeth. . . . The crowns of the canines [= lateral incisors] are considerably wider than those of the incisors [= median incisors], but do not project very far beyond them. They are sub-triangular in outline,

[13] American Journal Science, Vol. V, 1873, p. 410. Ibid., Vol. XXVI, 1908, p. 60, Fig. 13.

[14] American Naturalist, Vol. XIII, 1879, p. 333.

having a prominent shoulder at the base on their inner side. . . . Diastema long; ascending ramus vertical, flat in front. Depth of ramus at last molar .065; length of crown of canine [= lateral incisor] .027; width of do. at the base .024."

This type specimen, now in the Cope collection of the American Museum of Natural History, has recently been studied by the writer. After a comparison with fragments of the lower jaw associated with a skull (No. 10,005) of *Diceratherium armatum* in the Yale Museum I think it possible that this specimen may pertain to that species. The thick and rather shallow ramus of Cope's type is characteristic of *D. armatum.* The symphysis is similarly long and heavy, the mental foramen is below P_1, as in the latter species, and the comparative measurements of the two specimens agree fairly well. The question of the relationship of these two species cannot, however, be entirely satisfactorily settled until more complete material of the John Day forms is obtained.

Additional Measurements of Type of D. truquianum Cope.

Antero-posterior diameter of crown of median incisor	6 mm.
Transverse " " " " " "	8 "
Height " " " " "	$6\frac{1}{2}$ "
" " " " lateral "	$26\frac{1}{2}$ "
Transverse " " " " " "	23 "
Antero-posterior " " " " M^2	44 "
Transverse " " " " "	28 "
Anterior-posterior " " " " M^3	46 "
Transverse " " " " "	27 "

5. **Diceratherium petersoni** Loomis[15] *incertæ sedis.*

Type.—First and second molars of left side. Amherst Museum, No. 1583.

Horizon.—Miocene.

Locality.—Agate Spring Fossil Quarries (quarry A) Sioux County, Nebraska.

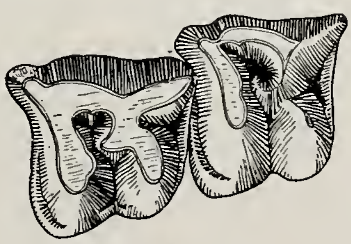


Fig. 9. *Diceratherium petersoni* Loomis. M^2 and M^3 left side. No. 1583, Coll. Amherst Museum. × ½. After Loomis.

In the extensive collection from the Agate Spring Quarries and neighborhood now in the Carnegie Museum, there are not found any teeth or other remains

[15] Amer. Jour. Sci., Vol. XXVI, July, 1908, p. 57, Fig. 7. Cook, Harold J., Neb. Geol. Surv., Vol. VII, Aug., 1912, p. 40.

comparable in size with this species. On the whole the configuration of the crowns of these teeth, as represented, does not greatly disagree with that of the type of *D. niobrarense*; one of the teeth being of a considerably younger individual than the latter. The size of the species of Loomis is, however, decidedly larger than *D. niobrarense.* If this does not prove to be a very large individual of the latter form, it may be a distinct species; possibly in a more direct line from the large form *D. gregorii* sp. nov., of the lower Rosebud beds of South Dakota (See page 421).

6. **Diceratherium armatum** Marsh.[16] (Plate LVII and text-figure 10.)

Type.—Complete skull somewhat crushed dorso-ventrally. Bones of fore foot associated. Peabody Museum of Natural History No. 10,003.

Horizon.—Lower John Day Formation (?Lowermost Miocene).

Locality.—Near John Day River in eastern Oregon.

As is well known, the genus *Diceratherium* established by Professor O. C. Marsh in 1875 rests on this famous specimen in the Peabody Museum of Natural History. The type was only briefly described by Marsh. Since that time no

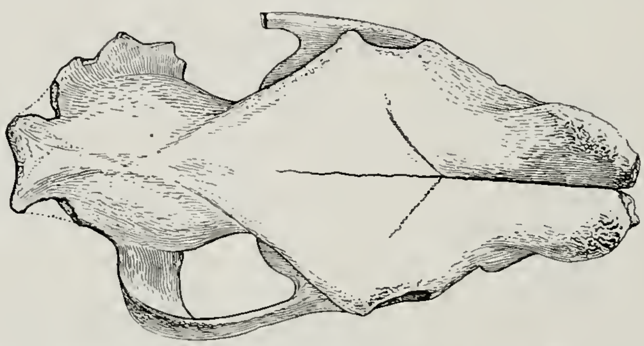


FIG. 10. *Diceratherium armatum* Marsh., No. 10003, Coll. Peabody Museum of Natural History. Top of cranium. $\times \frac{1}{6}$.

complete illustrations or detailed description of its osteological structure have appeared. For the purpose of more detailed records the writer was accorded the privilege of studying the type material in the Peabody Museum. The descriptions and illustrations of the type material follow the modified generic determination of *Diceratherium* and the specific characters of *D. armatum.*

GENERIC CHARACTERS ESTABLISHED BY PROFESSOR MARSH (MODIFIED).

Males with osseous protuberances on the anterior portion of the nasals. Females ranging from those with light or incipient nasal protuberances to those with nasals more or less smooth. Incisors $\frac{1}{2}$, *Canines* $\frac{0}{0}$–$\frac{1}{0}$ [*in rare cases a very minute canine persists*]. *Premolars* $\frac{4}{4}$, *Molars* $\frac{3}{3}$. *Fore and hind feet functionally tridactyl.*

[16] Amer. Jour. Sci., Vol. IX, 1876, p. 242; Ibid., Vol. XXVI, 1908, p. 54, Fig. 2.

Specific Characters.—Diceratherium armatum may be characterized as follows: *Frontals relatively broad over the orbits. Sagittal crest short. Inion light. Broad and heavy nasals. Anterior nares not extended as far back of the horn-cores as in D. cooki. Muzzle and premaxillaries long. Postglenoid and paroccipital processes well separated. Cheek-teeth comparatively simple in the configuration of their crowns. Animals of larger size than tapirs.* [?*Median lower incisors proportionally large.*]*

General Description.—As stated above, the type specimen of this species is somewhat depressed by crushing. In the Peabody Museum collection is an additional specimen, a skull with fragments of the lower jaws, re-identified by Professor F. B. Loomis. This second specimen has the contour of the top much better preserved. From these two specimens it is at once observed that the frontals are quite broad over the eyes, which causes a rather short, sharp, emargination of the muzzle back of the horn-cores. The latter are, as in *D. niobrarense,* located near the lateral border of the nasals; they are well developed though somewhat less in proportion to those in *D. annectens* of the same horizon. The nasals as a whole are, however, heavier than in the later forms from Nebraska, *D. niobrarense* and *D. cooki,* while one might look for evidence to the contrary. Even when the crushed condition of the John Day type is duly considered, it seems clear that the nasals were not elevated over the premaxillaries as high as in the later Diceratheres from Nebraska. The temporal ridges are rather weak and the sagittal crest is not greatly developed and occupies a smaller antero-posterior area than in *D. niobrarense.* The inion is not nearly as heavy as in the latter form, resulting in a comparatively less saddle-shaped top. The nasals are unfortunately broken off in front of the horn-cores, but enough is present to indicate that they were of considerable length and possibly terminated in a rather sharp point. The premaxillaries are also broken off, but what remain of them indicates that they were of greater length than in the Nebraskan species. There is present a heavy lachrymal process in *D. armatum.* The palate is broad as are also the posterior nares. The anterior margin of the posterior nares extends even with the anterior face of M^2. The post-glenoid and paroccipital processes are well separated, indicating the condition found in earlier Rhinoceroses. That the alveolar border of the maxillary terminates more abruptly back of M^3 and the paroccipital process is less robust than in some of the Nebraskan species are perhaps characters of less importance.

The dentition of the type is perhaps better known than any other part of the

* The only lower jaw of a large species with median incisors present is *D. truquianum* Cope. If the latter species should prove to be identical with *D. armatum* Marsh, then the above specific character is valid.

type specimen. This is due to the studies of Professor Marsh and later students. Therefore it is only necessary to here state that the ectoloph is perhaps thinner, the excavations or valleys of the crowns larger, and the cross-crests simpler, than in *D. annectens* or later forms from the Nebraska Miocene. P^1 is also observed to be proportionally large, and the cingulum seems to be well developed, especially on the internal faces of the teeth.

A case of reversion, or at least a non-uniformity of tooth-structure worthy of note, is seen in the second specimen of *D. armatum* in the Yale Museum collection (No. 10,055). The metacone on P^2 of the right side of this specimen displays a curious primitive roundness, though connected with the ectoloph by the usual thin cross-crest, while the corresponding tooth of the opposite side has this postero-internal tubercle of the usual type seen in the Diceratheres. There is otherwise little or no differences in the dentition from that in the type, except that No. 10,055 represents a younger animal. The crista, crochet, etc. are very little or not at all indicated, while the cingula are prominent, especially internally.

With the skull No. 10,055 of the Yale Museum collection, referred to *D. armatum,* there are associated fragments of lower jaws, which undoubtedly belong with the skull, inasmuch as the third molars, both upper and lower, are not yet entirely developed. These fragments of the lower jaw indicate that the horizontal ramus was very heavy, but rather shallow, the symphysis strong, the mental foramen of large size, and located directly below P_1. The roots of the lateral incisors indicate that the crown was large and most likely of the usual type met with in the family. The symphysis is broken off too far back to show any indication of the median incisors. P_1 has a rather small antero-posterior diameter, but the crown is quite high; the tooth is broken externally and the grinding and internal faces are buried in the matrix. This is also true of P_2. The external face of the latter tooth shows a very heavy cingulum, which extends around the entire posterior face, but has a less upward oblique trend than is seen in the later forms from Nebraska. The crowns of the cheek-teeth are little worn, indicating the juvenile stage of the specimen. M_2 has also a cingulum on the external face which is, however, less developed than on P_2; this is especially true of the posterior lobe of M_2.

The fourth metacarpal associated with the type of *D. armatum* is rather long and broad, having a comparatively small antero-posterior diameter. The bone is somewhat crushed, but the proximal end is not distorted and indicates that the bone was not very thick fore-and-aft. The distal trochlea extends well up upon the anterior face of the metacarpal. Judging from the unciform, which is present, the carpus was fairly high.

MEASUREMENTS OF THE TYPE OF DICERATHERIUM ARMATUM.

Length of skull from condyles to end of nasals as preserved (Points of nasals broken off)	503 mm.
Length from occipital condyles to M^3	208 "
M^3 to end of maxillary (Point of maxillary broken off) approximately	166 "
Greatest width across the zygomatic arches	145 "
Greatest transverse diameter of occipital condyles	112 "
Transverse diameter of occipital plate	146 "
Inferior surface of condyles to end of inion	159 "
Length of dentition (molar-premolar series)	248 "
Antero-posterior diameter of P^1	29 "
Transverse " " P^1 (greatest diameter)	24 "
Antero-posterior " " P^2 " "	31 "
Transverse " " P^2 " "	40 "
Antero-posterior " " P^3 " "	35 "
Transverse " " P^3 " "	45 "
Antero-posterior " " P^4 " "	38 "
Transverse " " P^4 " "	49 "
Antero-posterior " " M^1 " "	44 "
Transverse " " M^1 " "	53 "
Antero-posterior " " M^2 " "	53 "
Transverse " " M^2 " "	53 "
Antero-posterior " " M^3 " "	45 "
Transverse " " M^3 " "	50 "
Length of Mc IV	187 "
Greatest transverse diameter of head of Mc IV	51 "
Transverse diameter midway of shaft of Mc IV	40 "
Antero-posterior diameter of shaft of Mc IV (approximately)	15 "
Height of unciform	54 "

7. **Diceratherium annectens** (Marsh).[17] (Plates LXIII, Fig. 6; LXVI, Fig. 1, and text-figs. 11 and 11*a*.) (See Pl. LVIII, Figs. 1, 2, 3.)

Synonym.—Diceratherium nanum (MARSH).[18]

Type.—A set of superior premolars of the left side; one superior incisor associated. Peabody Museum of Natural History No. 10,001.

Hypotypes.—Skull nearly complete. Cope Collection, American Museum Natural History, No. 7324, a male. Front of skull and lower jaws of Professor Marsh's type *D. nanum* in the Marsh Collection, Peabody Museum of Natural History, No. 10,004, a male.

Horizon.—Lower to Middle John Day Formation.

Locality.—Near John Day River in eastern Oregon.

[17] Marsh, O. C., Amer. Jour. Sci., Vol. V, 1873, p. 4. Loomis, F. B., Amer. Jour. Sci., Vol. XXVI, 1908, p. 54, Fig. 3.

[18] Marsh, O. C., Amer. Jour. Sci., Vol. IX, 1875, p. 243.

Specific Characters.—*Premaxillaries long and slender. Nasals and nasal horn-cores of males broad and heavy. Muzzle long. Anterior nares excavated back of the horn-cores in the same proportion as in D. armatum. A well-defined and quite heavy sagittal crest. Occiput overhanging, and the cranium well extended back of the posterior angle of the zygomatic arches. Liberal separation between the postglenoid and paroccipital processes. First premolar relatively large. Cheek-teeth with swollen cross-crests and crowns otherwise complicated; crista and crochet present, especially on the posterior premolars and the molar series. Median and lower incisors proportionally large. Animal about the size of, or larger than, a tapir.*

General Description of the Type Material.

From recent studies of the type material of Professor Marsh's collection in the Peabody Museum and the splendidly preserved skull in the Cope Collection of the American Museum there is now no valid reason for regarding the types of

Fig. 11. *Diceratherium annectens* (Marsh). No. 10001, Coll. Peabody Museum of Natural History. Premolar teeth of left side and superior incisor. $\times \frac{1}{2}$.

D. annectens and *D. nanum* as belonging to separate species. *D. annectens,* having been described before *D. nanum,* and also being now found to possess sufficient characters for identification and comparison, must be regarded as the type.

In his description of *D. annectens* Professor Marsh was apparently not entirely clear as to the composition of the specimen. Professor Loomis correctly associates the type, but mistook some of the premolars for molars.

There is no doubt in the mind of the present writer that this series of premolars belongs to one individual. In placing the teeth together one finds that they fit against one another perfectly and the grinding surfaces form a natural gradation generally obtained in specimens of *D. cooki* which have reached an equal stage of wear. Whether or not the associated incisor tooth belongs to the type is less satisfactorily determined, as it has received comparatively little wear and appears small in proportion. The small amount of wear of the upper incisors is, however, often found in skulls of *D. cooki,* when the cheek-teeth have been well ground down.

P^1 is very much worn, so that its configuration is practically obliterated. P^2 is also much worn, but plainly indicates that the cross-crests are more swollen than in the larger species, *D. armatum*, so that on extreme wear of the tooth the two crests become almost united internally and more nearly approximate the condition in the Nebraskan form *D. cooki*; there is a slight indication of a crochet in P^2. P^3 has the internal portion of the cross-crests even more closely united, so that on extreme wear the tooth has a remarkably close similarity to that in *D. cooki*. There is, however, no crochet shown in this worn tooth; the crista might be said to be represented by a heavy fold on the inner face of the ectoloph. P^4 in its general characters is practically a repetition of P^3, except that the crista and crochet are more plainly shown. The crochet of P^4 of this species represents, undoubtedly, the most external process of the comb-like plate on the posterior border of the medifossette in *D. cooki*; that is to say, the true crochet, which unites with the ectoloph on extreme wear of the tooth. In the forms of the John Day it appears that this crochet does not entirely unite with the ectoloph.

No. 10,004 of the Yale Museum Collection (Marsh's type of *D. nanum*) is laterally compressed by crushing. As a consequence the nasals appear less broad than otherwise would be the case, and they are also possibly somewhat lengthened by crushing. The horn-cores are well-developed and the points of the nasals are quite heavy, and extend well in front; their tips are broken off. The nasals as a whole are heavy and are elevated above the premaxillaries much as in later forms, thus presenting large anterior nares. The infra-orbital foramen is large, well up upon the maxillary and its posterior margin is opposite the middle of P^3. The premaxillary is long; it is also slender, though somewhat heavier than in the later forms from Nebraska. There is a large upper incisor of the usual cutting pattern. The premolars are very much worn.

The lower jaws of the same specimen are also slightly crushed laterally. The most noteworthy feature of these jaws are the proportionally large median incisors and the long diastemata from the cheek-teeth to the incisors. The lateral incisor is robust, well sharpened by wear and procumbent in position. The cheek-teeth are much worn, indicating the senility of the individual. There is a fairly well developed cingulum on the lower premolars (Pl. LVIII, Figs. 1–3.)

As in the lower jaw of *D. armatum*, the ramus is quite heavy, but somewhat deeper in proportion. The internal face is also less convex supero-inferiorly. This latter character may in part be due to crushing.

As stated above, the skull (No. 7324 Cope Collection) in the American Museum is by far the best of the three specimens here described. (See Pls. LXIII Fig. 6;

LXVI, Fig. 1 and text fig. 11*a*.) From this material combined we are now in possession of practically all the anatomy of the skull of *D. annectens*. With the exception of the ends of the nasals, the anterior portion of the left horn, and the points of the premaxillaries this specimen is quite complete. The skull is somewhat depressed, so that the region about the horns and anterior portion of the maxillaries appears broader than in the New Haven specimen described above; however, the present specimen is in reality more robust. In proportion the horn-cores of *D. annectens* from the John Day are considerably heavier than in the later Nebraskan species and the tips of the nasals were evidently quite long. The constric-

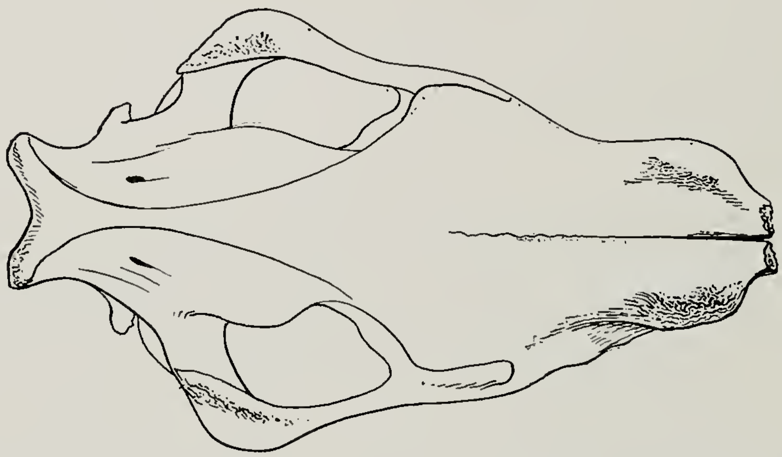


FIG. 11*a*. *Diceratherium annectens* (Marsh). No. 7324, Cope Collection, American Museum of Natural History. Hypotype. × ¼.

tion between the orbit and the nasal horn is, as in *D. armatum*, much shorter and sharper than in *D. niobrarense* or *D. cooki*, and the occiput extends further back of the posterior angle of the zygomatic arch and overhangs the occipital condyles to a greater degree. There is also a well-defined and quite heavy sagittal crest. The supratemporal ridges are distinct, but more gently oblique or more gradually converging towards the sagittal crest than in the Nebraskan species, which is due to the smaller brain-case in the form from the John Day. The occiput is somewhat more elevated above the occipital condyles and the transverse diameter of the occipital plate is actually less, though the skull is larger than that of the average skulls of *D. cooki* found in the Nebraskan quarries. As stated, the premaxillaries are broken off anteriorly, but it is very evident that the diastema from the cheek-teeth to the upper incisor in this specimen was as long as in the type at New Haven. The pre-orbital foramen is located above the anterior, or rather the middle, region of P^3 as in *D. cooki*, but it is further back of the narial border,

due to the longer muzzle of the form from the John Day. The zygomatic arch of the latter is somewhat lighter, especially at the posterior angle, which forms a less direct right angle with the side of the skull and is not nearly so rugose. The region back of the pterygoid processes is decidedly longer in the John Day species than in the eastern species. Thus there is a wide separation between the post-glenoid and paroccipital processes in the earlier species, while in the later form (*D. cooki*) these processes are closely united. Even the occipital condyles of the John Day specimen are less sessile. The anterior margin of the posterior nares is opposite the interval between M^1 and M^2 as in the smaller Nebraskan form, *D. cooki*, and the size of the nares is of the same proportion.

The premolars of the specimen in the American Museum are even more worn than in the type, which is brought out in the illustration, Pl. LXIII, Fig. 6. They are, however, not too far gone for identification and comparison, and they are seen to agree with the type in New Haven. M^1 has a decided antecrochet-like swelling of the anterior lobe, which is as great as, or perhaps greater than, in any of the Nebraskan specimens which I have seen. The crochet is of quite large size and totally separated from the ectoloph, so that at no stage of wear will this process apparently ever become united with the ectoloph as in *D. cooki*. M^2 has the crochet generally less developed than in *D. cooki*. M^3 has on the right side a curious basal cusp on the posterior margin of the exit of the median valley which is very similar to the same tooth in a specimen of *D. cooki* at the Carnegie Museum, though less deeply separated from the main body of the tooth. (See Fig. 4, p. 409.) On M^3 of the left side there is also a minute tubercle situated in a position similar to the one described above. With the exception of the relative size of the median incisor and the first premolars *D. annectens* from the John Day and *D. cooki* from the Nebraska Miocene differ less in the detailed structure of the dentition than was anticipated.

On page 422 are tabulated measurements of the specimens above described.

8. **Diceratherium gregorii**[19] sp. nov. (Plate LIX and text-figure 12.)

Type.—Skull,? female. American Museum, No. 12,933.

Horizon.—Miocene, Lower Rosebud beds.

Locality.—Near Rosebud Indian Agency, South Dakota.

Specific Characters: *Occiput low, but overhanging, as in the John Day form* (*D. annectens*) *Sagittal crest low, but well defined. Postorbital ridges converging very gradually, as in the John Day form, but the brain-case proportionally larger in size. Greater robustness of the inion, shorter basicranium and premaxillaries, when*

[19] In honor of Dr. W. K. Gregory, of the American Museum of Natural History, who found the type.

Measurements of D. annectens.

	Type, Y. M. No. 10001.	Neotype, Y. M. No. 10004.	Neotype, A. M. No. 7324.
Length of skull from inion to broken points of nasals			410 mm.
Occipital condyles to and including P^1			368 mm.
Occipital condyles to M^3			185 mm.
Greatest transverse diameter of skull at posterior angle of zygomatic arches			235 mm.
Transverse diameter of occipital plate. (Measurement taken superiorly)			83 mm.
Antero-posterior diameter of P^1, ^{2} and ^{3}			63 mm.
Length of upper dentition			185 mm.
Length of premolars	95 mm.		93 mm.
Length of molars			98 mm.
Antero-posterior diameter of P^1	21 mm.	*19 mm.	19 mm.
Transverse " " P^1	17 mm.	*18 mm.	17 mm.
Antero-posterior " " P^2	23 mm.	*23 mm.	24 mm.
Transverse " " P^2	27 mm.	*28 mm.	*28 mm.
Antero-posterior " " P^3	27 mm.		28 mm.
Transverse " " P^3	34 mm.		35 mm.
Antero-posterior " " P^4	29 mm.		30 mm.
Transverse " " P^4	38 mm.		39 mm.
Antero-posterior " " M^1			35 mm.
Transverse " " M^1			41 mm.
Antero-posterior " " M^2			40 mm.
Transverse " " M^2			41 mm.
Antero-posterior " " M^3			33 mm.
Transverse " " M^3			38 mm.
Length from P_1 to and including the lateral incisor		110 mm.	
Length of P_2 and P_3		48 mm.	
Length of P_2		23 mm.	
Length of P_3		26 mm.	
Antero-posterior diameter of crown of median incisor		8 mm.	
Transverse diameter of same		6 mm.	

* Approximate measurements.

compared with the John Day species, D. annectens. Paroccipital and postglenoid processes in close proximity to one another as in D. niobrarense. Border of anterior nares extending further back than in the latter species. Animal considerably larger than the tapir.

General Description.

The type specimen was discovered by Dr. W. K. Gregory of the American Museum party of 1906. The skull is somewhat depressed by crushing, which fact has been taken into due consideration. That the cranium may probably be that of a female should also be noted. The animal was of advanced age, as the dentition is greatly worn down and of no practical service for specific determination.

There is no true contact between the broken end of the premaxillary and the maxillary bone in the type at present, but Dr. W. D. Matthew assured me that it was complete when discovered, and that the length of the premaxilla is not far from correct as restored. (See Pl. LIX). Whether or not there was a lateral incisor, as in *Cœnopus tridactylus* from the Protoceras beds, cannot positively be

determined from the type. It is, however, most probable that this tooth is wanting, especially when we consider the proportionally small development of the premaxillary in the type, which is apparently much lighter and is no doubt shorter than, for instance, in *Cœnopus tridactylus* of the upper Oligocene. The later geological formation in which this new species was found is also to be considered. The

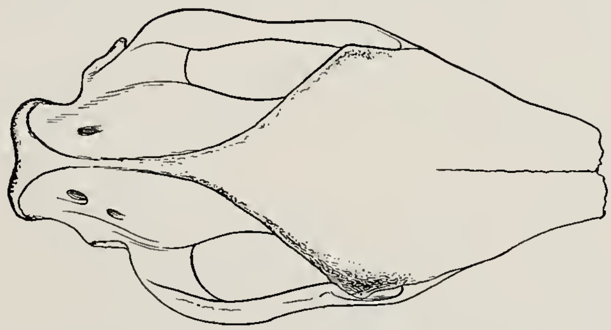


Fig. 12. *Diceratherium gregorii.* No. 12933, Coll. Amer. Museum. Top of cranium. × $\frac{1}{6}$

nasals were apparently of considerable length in front of the very slight swelling on the anterior portion of the nasals. The crushing of the anterior region of the skull gives to the anterior nares an unusually low position, low even when proper allowance is made for the distortion which has occurred. This may, or may not, be a valid character. The postorbital ridges of the frontals converge very gradually, somewhat as in the John Day form (*D. annectens*), but the brain-case is somewhat larger in proportion. The sagittal crest is low, but well-defined, and the inion is intermediate between the John Day form and *D. niobrarense* of the Nebraska Miocene, that is to say, the rise from the sagittal crest proper to the top of the inion is very much more gradual than in *D. niobrarense*, even when the difference of sex and the crushing sustained by the specimen is taken into account, thus more like what is seen in *D. annectens*, but the slight emargination on the posterior face of the inion is more as it is in *D. niobrarense*. The inion itself is less rugose and the lambdoidal crests are thinner than in *D. annectens*, which may be a sexual character. The top of the skull when in perfect condition was on the whole less saddle-shaped; the zygomatic arches lighter, less prominent posteriorly, and united with the sides of the squamosals more obliquely than in *D. cooki*. The postglenoid and paroccipital processes are in touch with one another, but are not so completely fused as in the latter species. The external ear is large and in shape more nearly as in *D. niobrarense*.

The incisor present in the premaxilla is of unusually small size in comparison with the cheek-teeth and the size of the skull. P[1] has about the same relative

size as in *D. niobrarense.* As stated above, the cheek-teeth are much worn. The last molar does not indicate any crochet or crista as in the last named species; the cingulum is, however, equally prominent. M^3 on the right side has a small cone in the median valley.

It is very likely that the above specific characters may be modified, or added to, when more material representing both sexes of this species is obtained.

MEASUREMENTS.

Greatest length of skull from inion to the end of the premaxillaries approximately	510 mm.
From occipital condyles to anterior end of maxillary, approximately	490 "
Occipital condyles to P^1	362 "
Occipital condyles to M^3	230 "
From incisor to orbit	197 "
From orbit to occipital condyles	310 "
Incisor to and including M^3	266 "
Greatest transverse diameter of skull at posterior portion of zygomatic arches	258 "
Greatest transverse diameter of frontals	191 "
Greatest transverse diameter at constriction back of the enlarged portions of the nasals	97 "
Length of molar-premolar series	217 "
Length of premolar series	102 "
Length of molar series	119 "
Antero-posterior diameter of P^1 (greatest diameter)	21 "
Transverse " " P^1 " "	20 "
Antero-posterior " " P^2 " "	26 "
Transverse " " P^2 " "	32 "
Antero-posterior " " P^3 " "	31 "
Transverse " " P^3 " "	44 "
Antero-posterior " " P^4 " "	34 "
Transverse " " P^4 " "	48 "
Antero-posterior " " M^1 " "	38 "
Transverse " " M^1 " "	45 "
Antero-posterior " " M^2 " "	45 "
Transverse " " M^2 " "	47 "
Antero-posterior " " M^3 " "	38 "
Transverse " " M^3 " "	44 "
Antero-posterior " " crown of incisor	19 "
Transverse " " " " "	9 "

9. **Diceratherium niobrarense** Peterson.[20] (Plate LX, Fig. 2; Pl. LXI, Fig. 2; Pl. LXII, Fig. 2, and text-figure 13.)

Synonym.—M. (Aceratherium) egrerius.[21]

[20] Science (N.S.), Vol. XXIV, 1906, p. 28; Ann. Car. Mus., Vol. IV, 1906, p. 46, Pls. XIII-XIV; Loomis, F. B., Amer. Jour. Sci., Vol. XXVI, 1908, p. 56.

[21] Loomis, F. B., ibid., p. 61 [*Aceratherium egrerius*]; Cook, Harold J., Amer. Naturalist, Vol. XLII, 1908, p. 543, 2 figs [*Accratherium egregius*]; [*Metacœnopus egregius*]; Neb. Geol. Surv., Vol. III, 1908, p. 245, Pl. I.; Vol. VII, 1912, p. 41.

Type.—Skull of young male. C. M., No. 1,271.

Horizon.—Miocene.

Locality.—Agate Spring Fossil Quarries (Quarry A.) Sioux County, Nebraska.

Paratype.—Posterior portion of skull from same quarry as the type. Vertebræ and limb-bones referred to same species.

Specific Characters.—Premaxillary somewhat reduced in length. Grinding surface of cheek-teeth comparatively simple. Nasals long in front of the horn cores especially in females. Muzzle long. Border of anterior nares comparatively little extended backward. Skull quite saddle-shaped, especially in males, due to the development of the horn-cores and the high inion. Postorbital ridges less oblique than in the John Day forms due to the enlargement of the brain-case. A sagittal crest present; this is proportionally long, but not especially strong. Zygomatic arches somewhat more expanded posteriorly and the basi-cranium shorter than in earlier John Day forms. Paroccipital and postglenoid processes sometimes touching one another at their bases so as to enclose the external auditory meatus. Lower jaws heavy and the angle little or not at all everted. Animal smaller than D. armatum of the John Day formation.

General Description.

Since the earlier descriptions of this species the type has been restudied. Illustrations, which in some respects are more accurate than those which appeared earlier, are also herewith presented. I, furthermore, add data recently obtained, and have corrected certain errors, which occurred in earlier publications.

In Science (*l.c.*) it was stated that the nasals were found in the talus below the point where the skull was taken out. The nasals were separated from the skull at the fronto-nasal suture, but agree with the skull found *in situ*, with the corresponding parts missing. I at once associated the different parts as those of one individual, and have not since found any reason for changing my mind. Confirming my view, a good skull of this species in Dr. Loomis' collection at Amherst has the fronto-nasal suture quite open, as in the type. Dr. Loomis assures me that the nasals belong with the skull of his specimen, which is of approximately the same age as the type. (See Fig. 13.)

In the original description it was said that the brain-case is large, while Loomis states that the brain-case is comparatively small, a statement which only holds good so far as the present species and *D. cooki* are concerned. From the earlier John Day forms *D. niobrarense* may be distinguished by its having the brain-cavity of larger size. I stated that there is a well-formed sagittal crest, but I did not especially emphasize the fact that the crest is strong. From the Amherst

material it appears that there is some variation in this respect, judging from the statements of Dr. Loomis. The statement made by the latter author that the nasals project considerably beyond the horn-cores is characteristic of this species, while in *D. cooki* the points of the nasals are much abbreviated in fully adult or old males.

The muzzle of the skull in *D. niobrarense* is apparently not shorter than in the John Day forms, while the constrictions back of the horn-cores and in front of the orbits are longer and gentler, due to the relative narrowness of the nasals across the horn-cores and the narrower frontals. The location of the infra-orbital foramen is similar to that in *D. armatum*, located well back from the border of

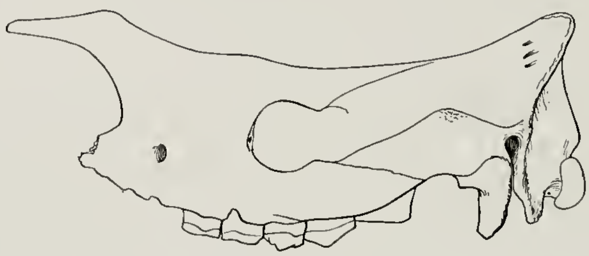


FIG. 13. *Diceratherium niobrarense* Peterson, No. 1022, Coll. Amherst Museum. × $\frac{1}{6}$. After an outline drawing by Dr. F. B. Loomis.

the anterior nares due to the slight backward excavation of the latter. The occiput is, however, not overhanging, as in the John Day forms, while the external ear is sometimes enclosed below.

As has been shown by Loomis and Peterson the molar-premolar dentition of *D. niobrarense* is more primitive than in *D. cooki*, and more nearly like that of *D. armatum*. In the latter species, which is clearly an older and rather primitive type, we find that P^1 is somewhat larger, the ectoloph of the grinders is thinner, the different valleys wider, and the cingulum perhaps somewhat more prominent. To judge from the scanty remains of *D. armatum* which we possess, it certainly is indicated that the crista is practically wanting, while the crochet is in a very much more rudimentary stage of development on the teeth of the latter species than in *D. niobrarense.*

In comparing the descriptions and figures of *Aceratherium egrerius*, later called *Metacœnopus* (*l.c.*) by Mr. Harold J. Cook, it is very evident that the remains of an adult female of *Diceratherium niobrarense* has been used as the type. Cook admits that there is a "thickening of the nasals at the point where a horn usually occurs in the Rhinocerotidæ, which may indicate a rudimentary horn." Indeed one should expect to find this thickened condition, and we usually do find it in

the young males and in female skulls of *D. cooki* of more adult stages. It appears that in males of *D. niobrarense* the nasal horn-cores are located more laterally and point more outward,[22] while in *D. cooki* they are nearer the median line and point more directly upward. (See Pl. LXII.)

With the exception of the longer nasals in front of the thickening portion or the incipient horn-cores (undoubtedly a sexual character), Mr. Cook's description agrees quite well with the type of *D. niobrarense.*

The premaxillaries are complete in this splendidly preserved specimen in Mr. Cook's collection, and show some reduction in length from those in the older John Day forms.

There is a considerable portion of the left mandible in Mr. Cook's specimen, which was found in an articulated position on the skull. Cook states that this mandible is "heavier and lacks the outward turn or flange commonly found in the Diceratheres." A splendid pair of lower jaws in the Loomis collection at Amherst (see Fig. 14) referred to *D. niobrarense* also agrees with the characteri-

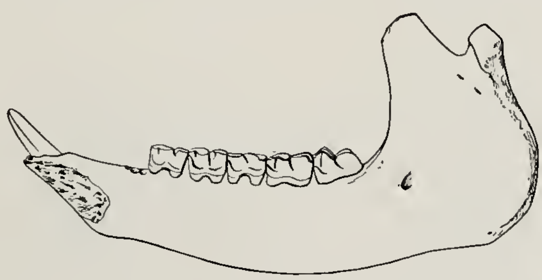


FIG. 14. *Diceratherium niobrarense* Peterson, No. 1022, Coll. Amherst Museum. Internal view of ramus. × 1/6. After an outline drawing by Dr. F. B. Loomis.

zation in Cook's paper, and plainly indicates that the masseteric muscle was much less developed in this species. Unfortunately the outline drawing kindly furnished by Professor Loomis from the Amherst specimen does not indicate the external view of the mandible.

The atlas and axis of Mr. Cook's specimen were found attached to the occipital condyle and are so illustrated in his paper. No description in detail of these vertebræ is, however, furnished.

A series of cervicals (atlas, 3d, 4th, and 6th), an anterior dorsal (?5) and three lumbar vertebræ were found isolated in the same quarry (quarry A) in which the type of *D. niobrarense* and the Amherst material was found. These bones, No. 1910, are here provisionally referred to *D. niobrarense,* inasmuch as the size

[22] Figures on Plate I of Cook's illustrations show admirably well these lateral eminences although of an incipient stage most likely due to sex. Cook states that there is no double-horn tendency in his type.

corresponds very well to the type. All these vertebræ, except the atlas, are more or less mutilated, but enough is preserved to show that they are very similar to those bones in *D. cooki*, size excepted. In its proportions the atlas referred to is not unlike that of the smaller form (*D. cooki*), save that the transverse process is less extended forward and is somewhat heavier, especially along the terminal border. A second marked difference of this bone in the two species is the presence

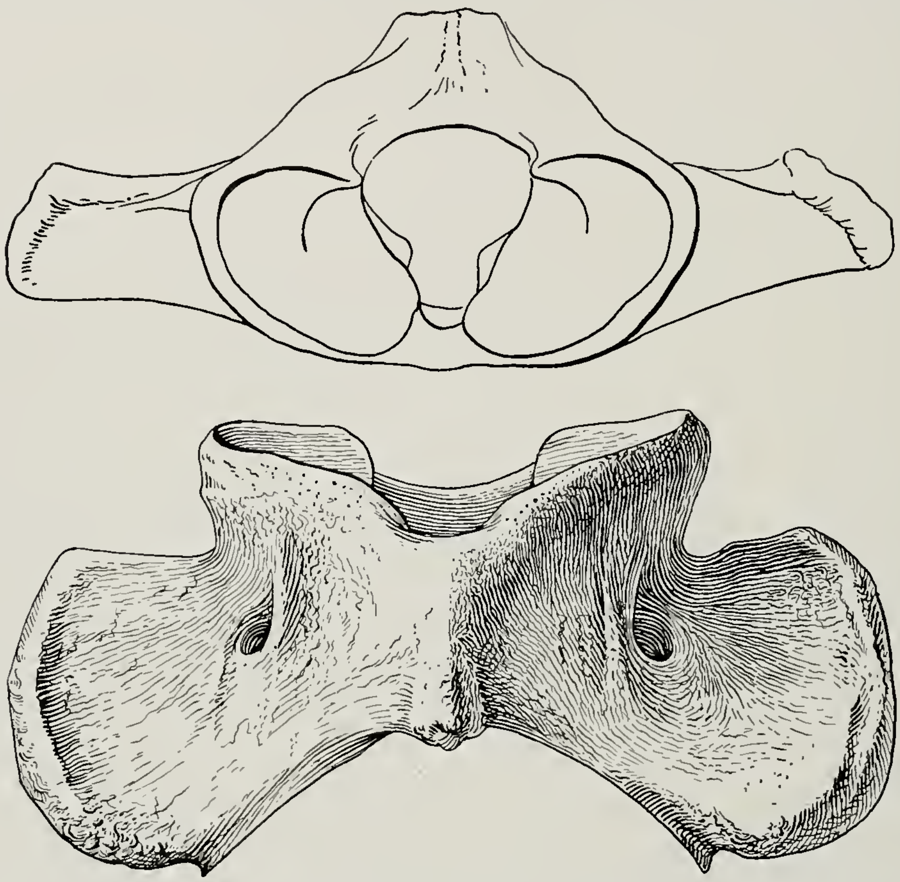


Fig. 15. *Diceratherium niobrarense* Peterson, No. 1910, Coll. Carnegie Museum. Anterior and ventral views of atlas. × ½.

in *D. niobrarense* of a round venal foramen, (remnant of the inferior exit of the vertebraterial canal) on the ventral face at the base of the transverse process, and a strong antero-posteriorly directed ridge immediately internal to the foramen. While there is in *D. cooki* a groove and occasionally a minute foramen, located in the same position as the foramen described on the atlas of *D. niobrarense*, there is found no evidence of the ridge in *D. cooki*. If the heavy terminal border of the transverse process and the venal canal are constant in *D. niobrarense*, this may be regarded as an additional specific character. (See Fig. 15.) The third cervical

has the ventral keel of the same proportions as in the smaller species, and the same faintly indicated neural spine, and the strong transverse process similarly expanded laterally. Cervical four has the neural spine as prominent, but the back part of its transverse process is perhaps somewhat heavier than in *D. cooki*. Cervical six again has the same downwardly directed inferior lamella of the transverse process, which is, however, proportionally less developed fore-and-aft than in *D. cooki*. The dorsal vertebra referred to presents the same characters as the corresponding bone in the latter species, including the mammillary process on the upper anterior surface of the transverse process. With the exception of a somewhat more decided ventral keel and possibly a lighter spine, the lumbar series associated are of approximately the same relative size and detailed structure as in the smaller form, *D. cooki*.

The remains of the limb-bones (No. 1910) which were found in this same quarry, and are provisionally associated with the type of *D. niobrarense*, show that the scapula is proportionally shorter than in the smaller species, and possibly also somewhat broader; the coraco-scapular notch shorter and shallower; the bicipital groove of the humerus smaller; and the shaft of the ulna straighter. The proportionate length of the femur cannot positively be ascertained from the material at hand, but the tibia is decidedly shorter. The remains of the foot-bones associated bear no marked differences from those of *D. cooki*, except their larger size.

The type (No. 1040) of "*Metacœnopus*" (*Aceratherium*) *stigeri* in the Amherst College Museum is described by Dr. Loomis, and the right upper molar-premolar series is illustrated. Dr. Loomis says: "The small skull is elongated, light in build and rather narrow. The orbit is large and the zygomatic arch light. The premolar teeth are crowded, there being neither an anterior nor posterior cingulum, though one is developed along the inner face around the protocone, running out on the hypocone. Crista and crochet are wanting on these teeth of a rather old individual, except that on the fourth premolar there is a faint trace of a crista, and on the third premolar a small antecrochet is developed. On the molars the cingulum is reduced as in the premolars, and both crochet and crista are wanting. The protocone, however, is swollen, making a considerable fold as in European Diceratheres. *A. stigeri* is closely related to *A. egrerius* but is smaller, and has the cingulum on the premolars and the crochet on the molars less developed."

In the description of this complete skull the greatest stress is laid on the configuration of the grinding surface of the teeth, principally for the purpose of comparison. The illustration indicates an animal of old age, as Loomis states. The crista, if there was one, has consequently disappeared by wear. The crochet

most likely has likewise disappeared, or rather united with the ectoloph, while the cingulum may be lighter or even wanting. The cingulum has united (by the wear of the tooth) with the internal border of the grinding face, especially on the posterior portion. It is very evident, from the enclosed post-fossette that the dentition illustrated by Loomis is very much more worn than that of the type of *D. niobrarense.* Finally through the courtesy of Professor Loomis. I had the opportunity of restudying his type and find that the Amherst specimen as well as the description agree quite well with the average old female skulls of *D. cooki* in the Carnegie Museum.

Measurements of the Type of D. niobrarense.

Greatest length of skull, approximately	450	mm.
Length of skull from occipital condyle to and including P²	370	"
Length of skull from occipital condyle to M³	190	"
Greatest transverse diameter of skull	235	"
Greatest transverse diameter of brain-case	130	"
Greatest transverse diameter of frontals	150	"
Greatest transverse diameter of occipital condyles	103	"
Greatest transverse diameter of palate	68	"
Vertical diameter of the orbit	60	"
Length of 2d, 3d and 4th premolars and the molar series	185	"
Antero-posterior diameter of P²	26	"
Transverse diameter of P²	29	"
Antero-posterior diameter of P⁴	32	"
Transverse diameter of P⁴	36	"
Antero-posterior diameter of M¹	39	"
Transverse diameter of M¹	37	"
Antero-posterior diameter of M³	35	"
Transverse diameter of M³	39	"
Scapula, approximate height	280	"
Humerus, length	340	"
Tibia, length (No. 1910)	335	"
Tibia, length (No. 1910*a*)	310	"
Tarsus, height tuber of calcaneum not included, approximately	85	"
Tarsus, length of tuberosity of calcaneum	58	"
Metatarsal II, length	130	"
Metatarsal III, length	145	"

The occurrence of the material of the above described species in the Agate Spring Fossil Quarries is of considerable interest. *Diceratherium niobrarense* has only been found in Quarry A. The remains of this species may be said to be practically absent in the representative fauna of the quarries in the Carnegie or the University Hills (See Mem. Car. Mus. Vol. IV, Fig. 1, p. 205), while similar

remains representing *D. cooki* of these latter quarries are quite as abundantly mingled with the remains of *D. niobrarense* in Quarry A. The latter quarry is only a very short distance (300 yards) to the north of the main quarries and may possibly represent a somewhat earlier time; or, more probably, the sediments accumulated at this spot represent a different stream, which had its origin in, and flowed through a locality more favorable to this species.

10. **Diceratherium cooki** Peterson.[23] (Plates LX, LXI, LXII, fig. 1, LXVI, figs. 2, 4).

Synonyms.—Diceratherium arrikarense Barbour; *D. schiffi* Loomis; *Aceratherium stigeri* Loomis; *Diceratherium aberrans* Loomis; *D. loomisi* H. J. Cook.[24]

Type.—Skull of old male. C.M. No. 1572.

Paratypes.—Eight skulls, a number of lower jaws, and other skeletal material C. M. Nos. 1573, 1575, 1581, 1841, 1848, 1853, 1855, 1888, 2408, 2443, 2799.

Specific Characters.—Skull, especially of males, short and broad in its proportions. Median lower incisor small. Crowns of the upper cheek-teeth complicated. Crochet often uniting with ectoloph in much worn teeth. Muzzle short. Horn-cores of males prominent, but nasals not broad across the horns, and ends of nasals abbreviated. Females varying from those with no horns to those with incipient horns. Postorbital ridges seldom entirely meeting to form a sharp sagittal crest. Brain-case large. Occiput quite broad, of moderate height, and not overhanging. Premaxillaries short. Margin of anterior nares much excavated, extending well back of the horn-cores and the infra-orbital foramen situated close to the border. Posterior point of zygomatic arch greatly expanded laterally and covered with heavy rugosities in fully adult or old males. Basicranium short. Post-glenoid and paroccipital processes united to enclose the external auditory meatus. Animal considerably smaller than D. niobrarense.

General Description.

Skull.

As stated in the original description, this species rests on a number of skulls, lower jaws, and other skeletal material from which a male skull No. 1572 was originally selected as the type. In the first description it was stated that "the occiput is rather low, . . . the temporal ridges quite prominent, not uniting

[23] Science (N.S.), Vol. XXIV, Aug. 31, 1906, p. 282–283; Annals Car. Mus., Vol. IV, 1906, p. 47, Pl. XV, text-figs. 12–13; Vol. VII, 1910, p. 274–279, Pl. LXV; Loomis, F. B., Amer. Jour. Science, Vol. XXVI, July, 1908, p. 58.

[24] *D. arrikarense* Barbour, Science (N.S.), Vol. XXIV, Dec. 14, 1906, pp. 780–781, figs. 1, 2; *Aceratherium stigeri* Loomis, Amer. Journal Sci., XXVI, July, 1908, p. 60; *Diceratherium schiffi* Loomis, *l.c.*, p. 57; *D. aberrans* Loomis, *l.c.*, p. 59; *D. loomisi* Cook, Harold J., Neb. Geol. Surv., VII, p. 48–32, figs. 2–3.

to form a sagittal crest, but continuing separate to the inion where they join the lambdoidal crest." Loomis on the other hand states that the skull is relatively short and high, with high occipital crest and a moderate sagittal crest, formed by the confluence of the two ridges from over the orbits. This mistake is undoubtedly due in part to the illustration (Ann. Carn. Mus., Vol. IV, 1906, p. 48, Fig. 12) which does not accurately represent the top of the skull. This is remedied in the illustration given with this paper, Pl. LXII, Fig. 1.

Loomis further states that "on the premolars, the cingulum is greatly reduced, while the strong crochet is united with the feeble crista, thus isolating the median fossette. In like manner on the molars the cingulum is reduced to traces on the front, inner side, and rear of the teeth." While this description was undoubtedly based on the material in the Amherst Museum and answers some individuals of this species in the Carnegie Museum, the type specimen does not agree with his description. In the first place the internal faces of the premolars, except P^2 are incomplete. The said premolar has a prominent cingulum on the anterior and internal faces of the protocone, which is confluent by wear with the grinding face of the metacone. On the antero-internal angle of P^3 a prominent cingulum is indicated, the inner face of the tooth is otherwise, as stated, broken off as is also P^4 on the anterior inner angle (See Pl. LX, Fig. 1.) M^1 and M^2 are also damaged in this same region, but enough is preserved to indicate that the cingulum is as prominent as is the case in other skulls, which are more complete in this respect. P^2 and P^3 have the crochet united with the ectoloph through wear; no crista is shown, while the post-fossette is entirely isolated on P^3. P^4 has only a trace left of the crochet, but no crista; post-fossette nearly enclosed. M^1 has crochet united with the ectoloph by wear, and post-fossette enclosed. M^2 has a strong crochet and the crown is injured in the region of the crista. M^3 has a strong crochet and a fairly prominent crista. The entire dentition is much worn, plainly indicating an old individual. The distinguishing characters of *Aceratherium stigeri* and *Diceratherium schiffi* given by Dr. Loomis now appear to rest entirely on sexual characters and individual variation, the type of his proposed species being female skulls of *D. cooki*, while his species *D. aberrans* is established on D. P.^{2} of the left side as has already been pointed out.[25]

From Professor Barbour's description and figures of his proposed species *D. arrikarense* in Science, N.S., Vol. XXIV, 1906, p. 780, it is clear that he has described a male skull of *D. cooki* minus the dentition, while Mr. Cook's proposed

[25] Peterson, O. A., "Recently Proposed Species of the Genus *Diceratherium*," Science (N.S.), Vol. XXXVI, 1912, p. 801.

species, *D. loomisi,* is also established on a maxilla of *D. cooki* with deciduous teeth. (Neb. Geol. Surv., VII, 1912, p. 29.)

In comparing the crania of the abundant material of *D. cooki* with the earlier John Day forms, or even with *D. niobrarense* found in the same beds in which *D. cooki* is found in Nebraska, it is at once clear that *D. cooki* is a comparatively more specialized and modified type of the *Diceratherinæ.* We find in the male skull (1) a pair of prominent horn-cores set closely together on the nasals; the nasals themselves not nearly as heavy as in the earlier John Day forms; and the ends of the nasals much abbreviated as in more specialized or modified forms of the *Titanotheridæ*; (2) muzzle, premaxillaries, and the front of the lower jaws shortened and the lateral margin of the anterior nares extended further back of the horn-cores; (3) brain-case enlarged; occiput broadening and not overhanging; basicranium short, analogous to *Teleoceras* from the middle Miocene and the recent Rhinoceroses (*R. bicornis*); (4) zygomatic arches much expanded with heavy rugosities on the posterior angle, and the angle of the lower jaws heavy and very much

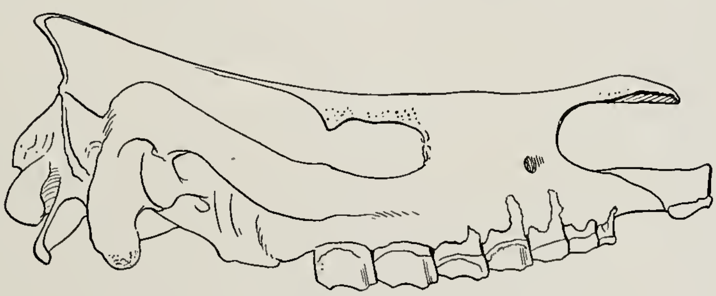


FIG. 16. *Diceratherium cooki* Peterson. No. 1853, Coll. Carnegie Museum. Skull of an old female. $\times \frac{1}{4}$.

everted to support heavy masseteric muscles; (5) the grinding surface of the cheek-teeth further complicated with a tendency on the part of the crochet to become united with the ectoloph, especially in teeth having received some wear.

As has already been stated in the introductory paragraphs of this paper, a greater range of variability must be allowed in dealing with female crania of this species. They range from those without horns in very young and immature females to those with incipient horns in fully adult and old individuals. The top of the skull is consequently comparatively little concave antero-posteriorly and the supratemporal ridges vary so much in their course to the inion that this region of the cranium may be said to range from a broad surface to a completely formed sagittal crest (this variation of the supratemporal and sagittal ridges holds good even in males, though to a somewhat less extent). Another feature of the female skull, no less noticeable, is seen in the longer pointed nasals, the

lighter zygomatic arches without the heavy rugosities on the posterior angle, and the less everted angle of the lower jaws. In connection with these characters the skeletal frame is lighter and the pelvic cavity proportionally somewhat larger, judging from the material at hand.

Mandible.

(Pl. LXVI, Figs. 2 and 4.)

As stated elsewhere[26] the lower jaws are heavy, especially those of the males. The depth of the ramus, however, is not great, and the diastema between the lateral incisor and P_2 is rather short. The symphysis, though short, is very heavy, and the median suture is entirely obliterated in old individuals. The angle is very greatly everted; in males the border of this everted area is very rugose, while in females and young the angle is less everted and is also less rugose, but still furnishes an unusual heavy surface for the masseteric muscles. The glenoid condyle is quite broad transversely and the coronoid process is strongly directed forward.

Dentition.—In proportion the median incisor is extremely small; it has a rounded enamel-covered crown, and is implanted in the symphysis by a thick short root; in many specimens this rudimentary tooth has dropped out. The lateral, or cutting incisor, is, as usual, comparatively large, but varying in different individuals. The canine is generally absent, even in the young. Occasionally this tooth is present in young individuals, and sometimes there is found on the alveolar border of the diastema a shallow groove, or scar, in which a minute canine is found in a very procumbent position. P_1 is absent. In young individuals a small milk-tooth is often found immediately in front of P_2 which persists in the alveolar border until all the cheek-teeth are erupted. On Pl. LXVI, Figs. 2 and 4 the characters of the cheek-teeth are well shown, and require no detailed description.

Only a very few hyoid bones are found mixed with the general mass of material in the quarries, there evidently having been during deposition too much disturbance for the preservation of these delicate parts.

In this connection it is interesting to turn to the work of Professor Henry F. Osborn, "The Extinct Rhinoceroses" Mem. Amer. Museum Natural History, Vol. I, 1898, pp. 136–140. In this publication, Osborn characterizes *Cœnopus* (*Aceratherium*) *mitis* from the lower Oligocene as follows (p. 139): "C_1[27], P_3, M_3, Diastema short. Canine[27] alveoli semi-procumbent. Premolar-molar series

[26] Peterson, O. A., Ann. Car. Mus., Vol. VII, 1910, p. 275.

[27] [= Lateral incisor.]

142 mm. Mandibular symphysis very short. Locality Colorado. Amer. Mus., Cope Collection, No. 6325."

This type specimen is accompanied by an upper maxillary with teeth and other skeletal material, but, as there seems to be some doubt as to their association, they will not here be considered.

A second specimen in the American Museum Collection from the upper Oligocene (Protoceras Beds) illustrated on page 139 of Osborn's work is especially interesting. This lower jaw (No. 1110) is doubtfully referred to *Cœnopus* (*Aceratherium*) *mitis* Cope, and exhibits just such characters as one might expect to find in an ancestral form of *D. cooki*: the short symphysis; the short diastema between incisor and cheek-teeth; the curving of the lower border of the ramus; and the angle everted as in *D. cooki*. The ramus itself is, however, deeper, the vertical ramus having a greater antero-posterior diameter, and the coronoid process a more nearly vertical position than in *D. cooki*, as indicated by the illustration. The measurements (p. 140) do not appear to agree completely with the illustrations.

This lower jaw undoubtedly represents a distinct species, judging from the great vertical depth of the sediments lying between the Titanotherium beds in which *Cœnopus mitis* (Cope) was found, and the Protoceras sand-stones, together with the general change in the fauna of these two geological horizons. This lower jaw from the Protoceras beds may here be provisionally regarded as the type of *Cœnopus dakotensis* sp. nov. and also provisionally placed in the line more or or less directly leading to *D. cooki* found in the lower Harrison beds of Nebraska as indicated in the table found in the introduction to this paper.

Vertebral Column.

The vertebral formula is provisionally given as follows: *Cervicals*, 7; *Dorsals*, 19 (?); *Lumbars*, 5; *Sacrals*, 4–5; *Caudals*, 26.

Cervical Vertebræ (Figs. 17–21). In a fully adult animal the width of the atlas is almost double that of the length. The anterior projection of the transverse process extends well forward. The neural canal is of moderately large size, while the arterial canal on the ventral face of the transverse process is generally lacking. The median area of the neural arch varies in different individuals in robustness and rugosity. The transverse process and the median tubercle of the lower posterior face of the body also vary in robustness and size.

The odontoid process and body of the axis are heavy; the neural spine is generally heavy and overhanging, while the transverse process projects rather strongly backward. The latter process is subject to much variation in size, as is

also the ventral keel. The arterial canal is indicated by a deep groove on the anterior border of the pedicel, which is often found completely bridged over by a

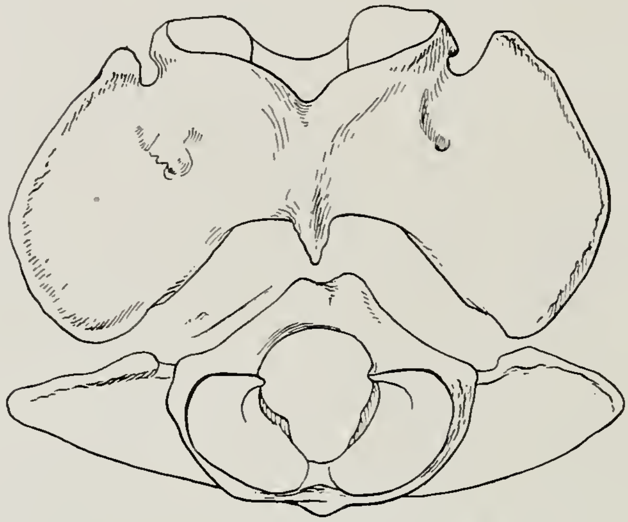


Fig. 17. *Diceratherium cooki* Peterson. No. 1853, Coll. Carnegie Museum. Ventral and anterior views of atlas. × ½.

thin splint of bone. Additional features of this bone are well shown in the illustrations. (See Fig. 18.)

The third, fourth, and fifth cervicals are, as usual, very uniform in their details

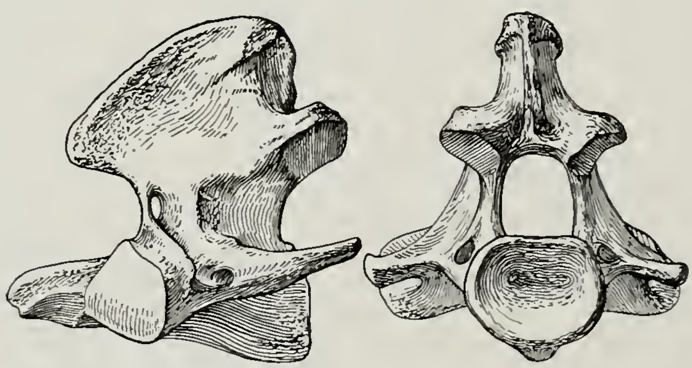


Fig. 18. *Diceratherium cooki* Peterson. No. 1853, Coll. Carnegie Museum. Lateral and posterior views of axis. × ½.

of structure. There is, however, no neural spine on the third; the fourth has a spine more or less clearly indicated; the fifth a spine of considerable size varying in length in different individuals.

The sixth cervical is characterized by the broad, thin, hatchet-shaped, inferior lamella of the transverse process, which sometimes terminates in a rounded process

behind. The superior, or transverse process proper, is located well up on the centrum; it is trihedral in cross-section, rather short, and projects strongly backwards. The neural spine of this vertebra is quite high, attenuated, of great antero-posterior diameter, and terminates rather abruptly.

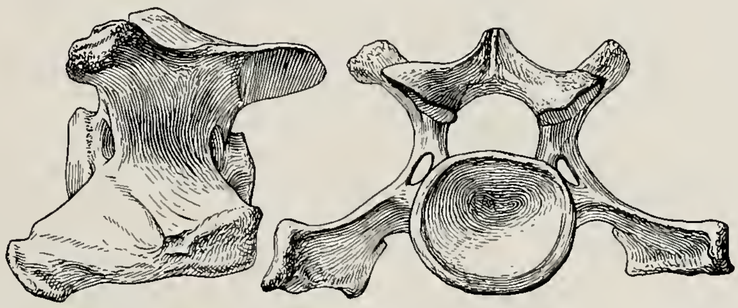


FIG. 19. *Diceratherium cooki* Peterson. No. 2499, Coll. Carnegie Museum. Lateral and posterior views of fourth cervical. × ½.

The neural spine of the seventh cervical is quite high and generally terminates in a sharp point. The transverse process is abruptly reduced and there is no vertebrarterial canal.

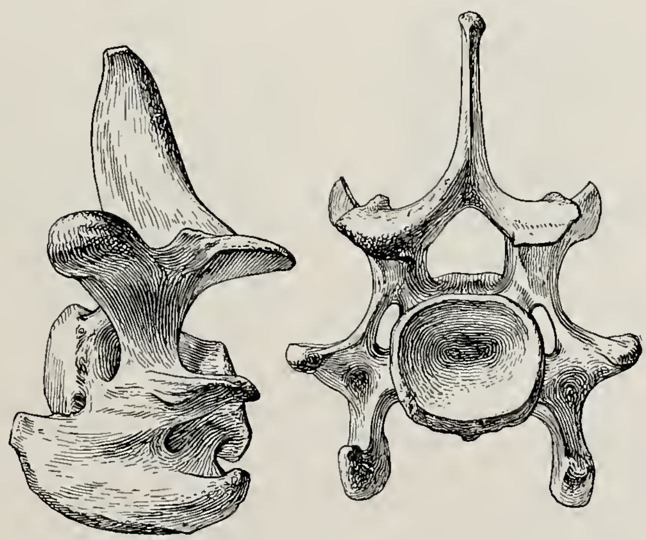


FIG. 20. *Diceratherium cooki* Peterson. No. 2499, Coll. Carnegie Museum. Lateral and posterior views of sixth cervical. × ½.

Dorsal Vertebræ (Figs. 22–24). We are not yet in a position to positively state the number of vertebræ in the dorsal series. In the skeletons articulated and those assembled for articulation and sent to other institutions by the Carnegie Museum there have been inserted nineteen. This number is thought to be ap-

proximately correct, as it corresponds with those in *Cœnopus tridactylus* Osborn which was found, articulated, in the upper Oligocene of South Dakota.[28]

The first dorsal vertebra is characterized by the proportionally large and high

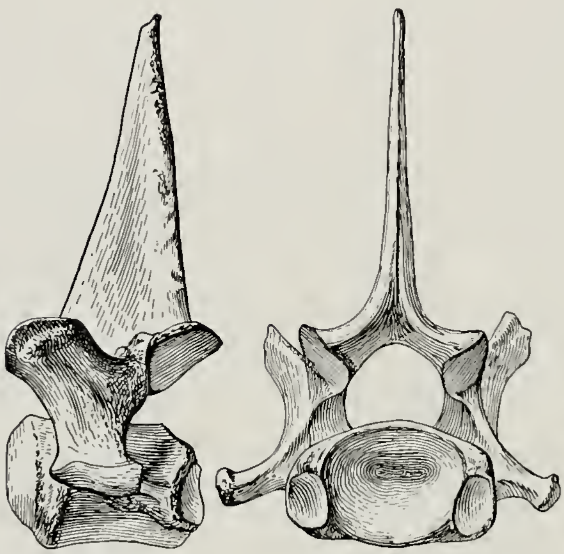


Fig. 21.

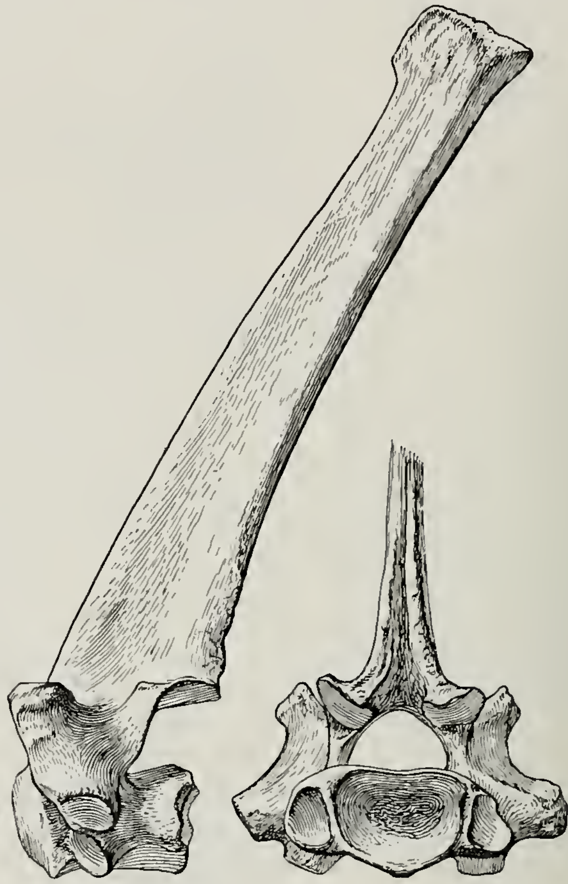


Fig. 22.

Fig. 21. *Diceratherium cooki* Peterson. No. 2499, Coll. Carnegie Museum. Lateral and posterior views of seventh cervical. $\times \frac{1}{2}$.

Fig. 22. *Diceratherium cooki* Peterson. No. 2499?, Coll. Carnegie Museum. Lateral and posterior views of first dorsal. $\times \frac{1}{2}$.

neural spine and the depressed centrum; the prezygapophyses are also much expanded laterally to receive the postzygapophyses of the last cervical. The articulations for the ribs are located very low on the side of the centrum and the pedicel is broad and heavy.

With the exception of the skull, there is probably no other part of the skeleton in this species which is subject to greater variation than the neural spines of the dorsal vertebræ. In specimens undoubtedly referable to adult and old males

[28] Osborn, H. F., Bull. Amer. Mus. Nat. Hist., Vol. V, 1893, p. 85.

the first dorsal spine is high, broad, and rugose, as shown in Fig. 22, while in many specimens, fully adult and old, this spine is 50 mm. shorter, and sometimes even more. In the anterior dorsals the curvature of the neural spine also varies from a comparatively straight spine to one with a gentle sigmoid curve. The latter are generally those with the longer and heavier spines. The neural spine of the second dorsal is suddenly reduced in size, but back of the second the reduction is more gradual. The anterior dorsals have short, broad, and depressed centra, while further back they are higher, narrower, and terminate ventrally in better defined keels. The intervertebral notch is deep and in the posterior upper side of the centrum it continues downward in a broad and well-defined groove, principally due to the greatly elevated border of the capitular facet on the centrum.

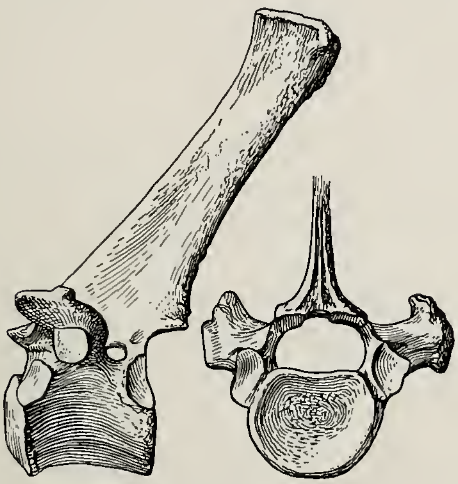


FIG. 23.

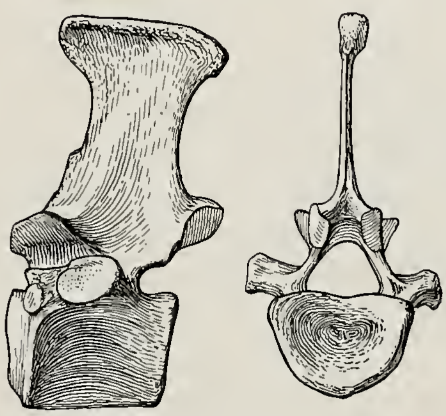


FIG. 24.

FIG. 23. *Diceratherium cooki* Peterson. No. 2499, Coll. Carnegie Museum. Lateral and posterior views of tenth dorsal. × ½.

FIG. 24. *Diceratherium cooki* Peterson. No. 2470*a*, Coll. Carnegie Museum. Lateral and posterior views of eighteenth dorsal. × ½.

In the neighborhood of the eighth, ninth, and tenth dorsals there is usually a foramen formed at this notch, which is characteristic of all posterior dorsals except the last. (See Figs. 23–24.) The fourteenth and fifteenth dorsals have the neural spines broader and more lumbar-like; the mammillary processes, so characteristic of the transverse processes of the dorsals are also longer and project forward in these vertebræ to a greater extent. The inferior aspect of the centra vary from a gently rounded to a more decided ventral keel, possibly due to sex.

Lumbar Vertebræ. Figs. 25–27. There are five lumbar vertebræ. This causes this part of the spinal column to be rather short. In general outline the

centrum of the first lumbar is not unlike that of the posterior dorsals, while further back the lumbar vertebræ are more depressed and gradually broadened. The last is broader than long. The last lumbar vertebra is otherwise conspicuous on

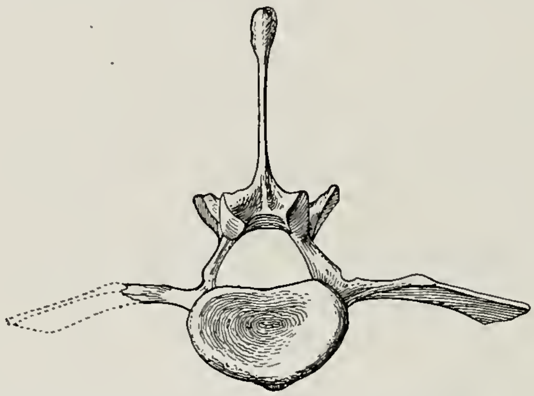


Fig. 25. *Diceratherium cooki* Peterson. No. 2470*a*, Coll. Carnegie Museum. Posterior view of second lumbar. × ½.

account of its suddenly reduced neural spine. This reduction is principally in the fore-and-aft direction so that there are broad vacuities between the spines in front and behind.

The more noticeable variations in the lumbar series result from the presence or the absence of an articulating buttress between the fourth and fifth lumbars.

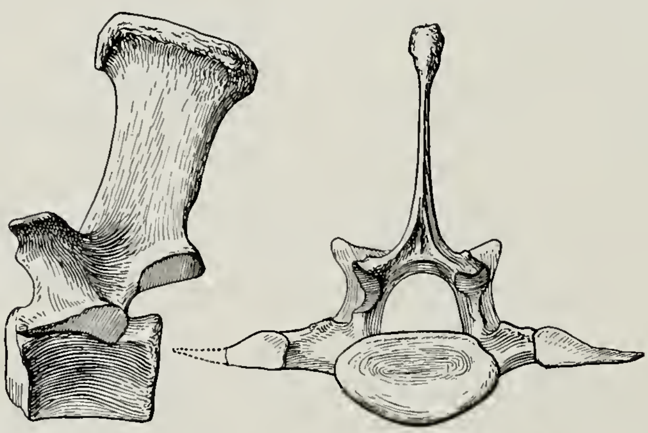


Fig. 26. *Diceratherium cooki* Peterson. No. 2470*a*, Coll. Carnegie Museum. Lateral and posterior views of lumbar four. × ½.

This articulation is located on the transverse process (posterior face) of the fourth, and meets a corresponding surface on the anterior face of the process on the fifth lumbar. (See figs. 26 and 27.) The first lumbar is sometimes found to possess an unusually long transverse process, which tapers rapidly and is rib-like.

Sacrum. Fig. 28. There are four and often five coössified centra of the sacrum. The two first vertebræ support the ilium, while those in the rear have sharp lateral edges and gradually taper toward the caudals. The neural spine of

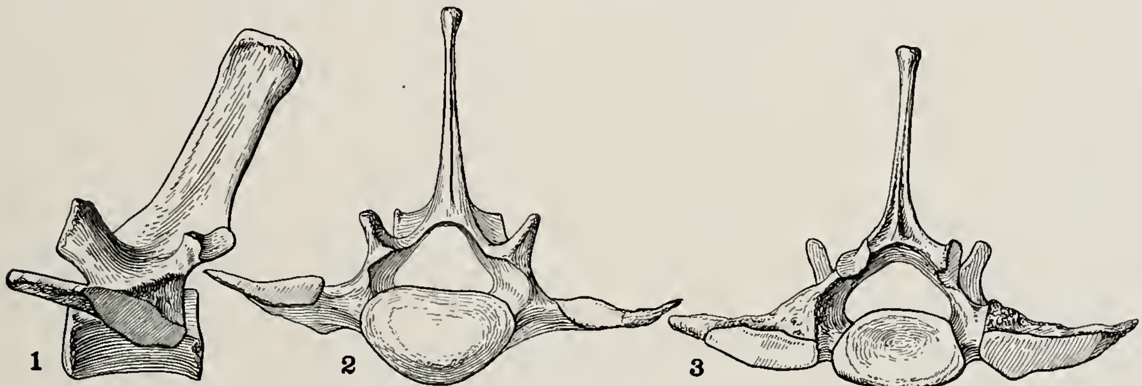


FIG. 27. *Diceratherium cooki* Peterson. No. 2470*a*, Coll. Carnegie Museum. 1, lateral view of fifth lumbar; 2, anterior view of same; 3, posterior view of same. × ½.

the first sacral is generally quite slender, but further back the spines are more robust. The sacral foramina are of large size and the coösification between the

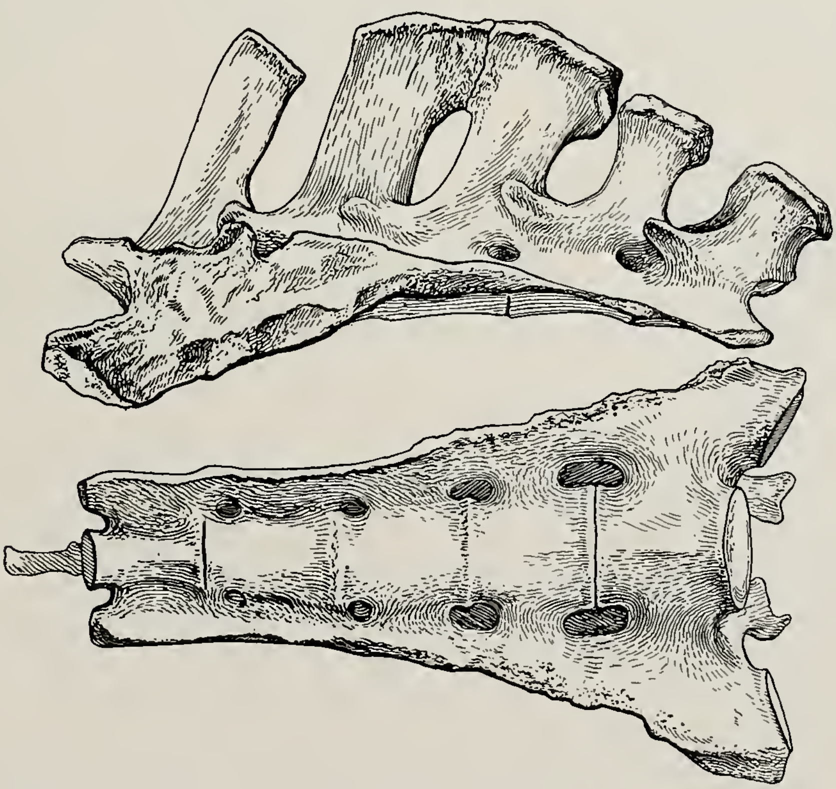


FIG. 28. *Diceratherium cooki* Peterson. No. 2797, Coll. Carnegie Museum. Lateral and ventral views of sacrum. × ½.

centra is complete, especially in fully adult or old individuals, there being little or no trace of a suture.

Caudal Vertebræ. Twenty-six vertebræ have been attributed to the tail. This is thought to be approximately correct, inasmuch as seventeen were found in consecutive order from the first to and including the seventeenth. The seventh caudal is the last with a complete neural arch, and the eighth is the last with traces of a transverse process. The tail as a whole is moderately long and tapers to a fine point as indicated by many very small vertebræ found in the collection.

Ribs.—The ribs, even the posterior, are rather long. In the anterior region they are flat, though not broad, while further back their cross-sections have a tendency to be more trihedral. There are well-defined tubercular facets throughout the entire series. Altogether the thorax forms a rather solid cylinder.

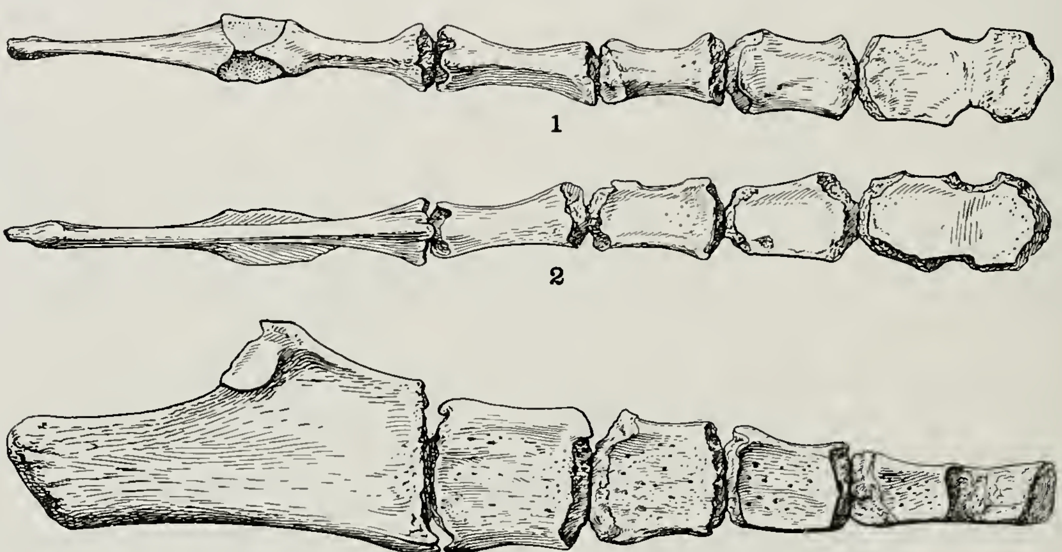


FIG. 29. *Diceratherium cooki* Peterson. No. 2817, Coll. Carnegie Museum. 1, Dorsal view of sternum; 2, ventral view of same; 3, lateral view of same. × ½.

Sternum. Fig. 29. The sternum was described in part as follows:[29] 'The manubrium is an elongated, laterally compressed, and vertically deep plate of bone. Anterior to the contact for the first pair of ribs there is a long heavy process, extending forward, and constituting the greater half of the entire length of the presternum. Posteriorly the bone is slightly expanded transversely and has a rough surface for the attachment of the mesosternum. The first two segments of the latter are somewhat deeper than wide. The posterior end of the fourth sternebra is nearly square in outline, while the fifth and sixth are broader than deep.'

[29] Peterson, O. A., Ann. Car. Mus., Vol. VII, 1911, p. 277.

Fore Limb.

Scapula. The scapula is long, narrow, and recurved. It is perhaps somewhat narrower than in earlier types (*C. tridactylus*, Osb.) and nearer the proportions found in more recent forms (*R. pachygnathus* or *R. bicornis* Wagn.) In general the outlines are very similar to those of these species. The coracoid is prominent, the supra-scapular notch quite deep. The spine, which nearly equally divides the supra- and infra-spinous fossæ, terminates in a very heavy and retroverted process. There is a third fossa at the coracoid border immediately above the suprascapular notch, which is separated from the supraspinous fossa by a

FIG. 30. *Diceratherium cooki* Peterson. No. 2473, Coll. Carnegie Museum. External views of scapula. × ⅓.

somewhat prominent vertical ridge. The fossa itself, however, is rather shallow and of relatively small size. (See Fig. 30). There is very little variation in the details of the scapula in fully adult animals, robustness and size excepted.

Humerus. The humerus is short and heavy. The tuberosities of the proximal end, though not as heavy in proportion as in some of the recent Rhinoceroses (*R. bicornis*), are nevertheless, very prominent and the bicipital groove has a tendency to become double, *i.e.*, separated by a broad, but very low ridge, approaching the condition in the recent Rhinoceros where the bicipital tubercle is more prominent. Distally the bone has furthermore a great transverse diameter due to

the large entepicondyle and prominent supinator ridge. The anconeal fossa is very deep and of considerable height (See Fig. 31.)

The proportionate length of the radius and ulna is approximately like that of *Rhinoceros bicornis.* In the fossil form the shafts of both radius and ulna are, how-

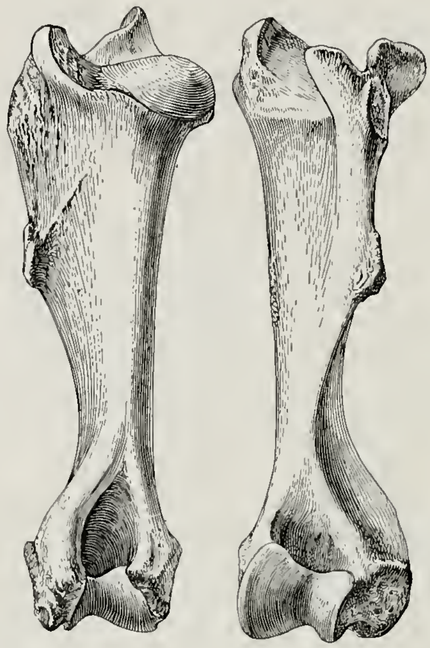


Fig. 31. *Diceratherium cooki* Peterson. No. 2473, Coll. Carnegie Museum. Posterior and anterior views of humerus. $\times \frac{1}{3}$.

ever, flatter than in the African species. In fully adult and old individuals this is chiefly due to the rugose and prominent ridges, which actually come in contact with each other throughout the whole length of the bones, while in the recent form the median region of the shafts is rounded and the two bones are separated by a considerable space. The shaft of the radius is quite straight, while the ulna as a whole is much bent backward, especially the upper half, a characteristic seen in the recent form. The carpal articulations differ from those in the African form to a marked degree. Thus the lunar articulates exclusively with the radius in *Diceratherium,* while in *R. bicornis* it encroaches to a considerable extent on the distal face of the ulna. On the other hand it is observed in a number of cases in *Diceratherium* that the cuneiform extends over upon the radius, forming a minute facet on the extreme ulnar border as well as on the palmar face. There is a considerable variation, especially in length and robustness, of the fore-arm of *D. cooki,* which is undoubtedly due to sexual and individual variation as well as age.

Manus. Pls. LXIII; LXIV. The height and breadth of the carpus are

practically equal, the height being sometimes very slightly greater than the breadth, while in the recent rhinoceros the breadth is a little greater than the height. The proximal facets of the scaphoid and cuneiform are not unlike those in recent forms, while the lunar lacks the facet for the ulna, so plainly shown in the African species. The large facets and the heavy palmar hook of the lunar uniting the lateral bones on the proximal row of the carpals in *R. bicornis* are conspicuously absent in *Diceratherium*. The second row of the carpals in the latter are higher than

Fig. 32.

Fig. 33.

Fig. 32. *Diceratherium cooki* Peterson. No. 2473, Coll. Carnegie Museum. Radial and dorsal views of ulna. $\times \frac{1}{3}$.

Fig. 33. *Diceratherium cooki* Peterson. No. 2499, Coll. Carnegie Museum. Oblique ulnar view of radius and ulna. $\times \frac{1}{4}$.

those in *R. bicornis*; otherwise there are only minor details of difference between the two forms. With regard to size, the trapezium and metacarpal V have approximately the same proportions as in the living species. The three functional metacarpals in *D. cooki* are decidedly longer, slenderer, and the shafts of II and IV are more curved. This curvature of the shafts of Mc II and IV is to conform to

the sides of Mc III to which bone they lie rather close with comparatively little divergence distally. All the phalanges are broad, short, and depressed. (See Pl. LXIII).

In *Cœnopus tridactylus* the metacarpals also are close to one another, but the lateral metacarpals are heavier in proportion than in *D. cooki*. This is also true of the bones in the hind foot. Another noticeable feature of the hind foot in *C. tridactylus* is seen in the proportionally larger size of the entocuneiform, which is not remarkable, when we consider the differences in size of the lateral metapodials in the two genera here compared.

Hind Limb.

The pelvis is short and broad. The area for the gluteal muscle is broadly expanded, but the supra-iliac border is emarginated as in *Cœnopus* of the Oli-

Fig. 34. *Diceratherium cooki* Peterson. No. 2797, Coll. Carnegie Museum. Left half of pelvis, dorsal view. × $\frac{1}{3}$.

gocene. The ischium and pubis are relatively short when compared with *Cœnopus tridactylus,* indicating quite an advance in the direction of the recent Rhinoceroses.

The acetabulum is well rounded and deep; the pit for the round ligament is quite deep and the cotyloid notch broad. The obturator foramen is very large and ovate in outline. The sciatic notch of the ischium is well-defined by the sudden termination of the spine and the heavy and suddenly upward, or outward, turned tuber ischii. The prominence of the latter tuberosity is subject to some variation

Fig. 35.

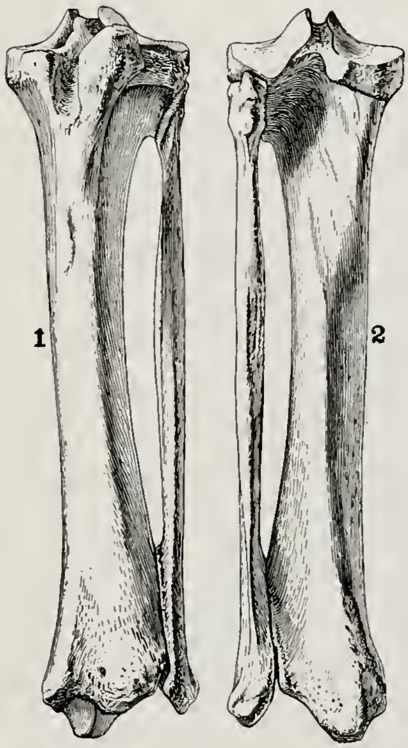


Fig. 36.

Fig. 35. *Diceratherium cooki* Peterson. No. 2460, Coll. Carnegie Museum. Posterior and anterior views of femur. $\times \frac{1}{3}$.

Fig. 36. *Diceratherium cooki* Peterson. No. 1840, Coll. Carnegie Museum, 1, anterior view of tibia and fibula; 2, posterior view of same. $\times \frac{1}{3}$.

in different individuals. In fact there is in this species a considerable degree of variation in the robustness of the pelvis in the large collection before us. This, in my judgment, is due to age and sex.

The femur is quite long. The shaft, when seen from the front, is quite straight, but on a rear view appears curved, due to the prominence of the different trochanters (See Fig. 35.) The third trochanter, though large, is not the long, forward, and

outward extending process seen in *R. bicornis.* Nor is the proximal end so much expanded laterally as in the African species.

The tibial border of the rotular trochlea is greatly developed; it has very nearly reached the extreme modernized stage of development seen in the recent Rhinoceros and the horse. The antero-posterior diameter of the distal end is therefore greater than the transverse in approximately the same proportion as in *R. bicornis.*

The patella is triangular in general outline, due to the large development of the internal process in order to cover the greatly developed internal border of the rotular trochlea described above. The trochlear grooves of the patella are quite uneven in size and the bone as a whole unlike that of the horse.

In fully adult and old individuals both ends of the tibia and fibula have a strong tendency to become coössified. This is a direct indication of the progressive development which has reached its culmination in the completely united tibia and fibula of *R. bicornis.* Like the femur, the tibia and fibula are rather long and slender, when compared with these bones in the recent species, and it also appears that

Fig. 37. *Diceratherium cooki* Peterson. No. 1840, Coll. Carnegie Museum. Posterior and anterior views of patella. × $\frac{1}{3}$.

these bones in *Cœnopus tridactylus* (Osborn) are proportionally shorter and possibly also somewhat heavier than in *D. cooki.*

Pes. Pls. LXIII, LXIV. As is already known, the pes is strictly tridactyl. It is on the whole narrow and quite high, especially when compared with *R. bicornis.* It is also somewhat higher and slenderer than the pes in *Cœnopus tridactylus.*

The tuber of the calcaneum has about the same general proportions as the European species *D.* (?) *croizeti* Pomel*, *i.e.*, it is quite heavy and of medium length, while the sustentacular facets are similar in detail. The broad and rather low astragalus also agrees in detail with that of this European form. The cuboid is quite high and has an extremely heavy process posteriorly. The metatarsals are quite elongated, the lateral metatarsals with curved shafts somewhat similar to those in the manus. The ungual phalanges are shorter than in the manus.

The remains of *Diceratherium cooki* constitute by far the greatest percentage of all the material found in the Agate Spring Fossil Quarries. Another significant

* Pomel referred the species to *Aceratherium.* Professor Max Schlosser identifies it as *Diceratherium* in the case of material sent to us from the Royal Museum in Munich.

Measurements of the Type of D. cooki.

Greatest length of skull	350 mm.
Length from occipital condyle to and including P^2	307 "
Length from occipital condyle to M^3	150 "
Greatest transverse diameter of skull	215 "
Greatest transverse diameter of brain-case	107 "
Greatest transverse diameter of frontals	140 "
Transverse diameter of nasals back of horn-cores	65 "
Transverse diameter of nasals at the horn-cores	70 "
Transverse diameter of palate at M^3	55 "
Vertical diameter of the orbit	30 "
Antero-posterior diameter of premolars two, three, and four	68 "
Antero-posterior diameter of the molar series	90 "
Antero-posterior diameter of P^2	22 "
Transverse diameter of P^2	23 "
Antero-posterior diameter of P^4	28 "
Transverse diameter of P^4	29 "
Antero-posterior diameter of M^1	34 "
Transverse diameter of M^1	32 "
Antero-posterior diameter of M^3	26 "
Transverse diameter of M^3	32 "

Measurements of Limb Bones of Skeleton.

Scapula, height	273 mm.
Scapula, width at superior border	138 "
Humerus, length	250 "
Ulna, length	315 "
Radius, length	250 "
Carpus, height	59 "
Carpus, transverse diameter	60 "
Mc II, greatest length	70 "
Mc III, greatest length	138 "
Mc IV, greatest length	115 "
Phalanges, median digit	70 "
Pelvis, total length	335 "
Pelvis, diameter across ilia	355 "
Pelvis, Diameter across acetabulum	220 "
Femur, length	323 "
Tibia, length	275 "
Tarsus, height of tuber of calcaneum not included	70 "
Tarsus, length of tuber of calcaneum	48 "
Tarsus, greatest transverse diameter	53 "
Mt. II, length	110 "
Mt. III, length	125 "
Mt. IV, length	110 "
Phalanges, third digit	30 "

fact is the great number of bones representing young animals and females in proportion to those of males. This would appear to indicate (1) that the animals were polygamous to a great degree and that the males were either struggling for the possession of the herds after the manner of recent ungulates (*Equus*), and were few, or, that they were strong enough to extricate themselves when overtaken by the calamities which destroyed the herds.

The articulated skeleton of *Diceratherium cooki* has been fully discussed in the Annals of the Carnegie Museum, Volume VII, pp. 274–279.

Modes of Development of Certain Dental and Bony Structures of the Cranium in Diceratherium.

(Plates LXV and LXVI.)

Important facts, in connection with the evolution of the dental formula and other features of the cranium of the Rhinocerotidæ, are obtained from the large collection under study in the Carnegie Museum. Some studies bearing on the evolution of the incisors and canines of *Diceratherium* were already presented before the Paleontological Society at Pittsburgh in 1910. The following pages are given to a further discussion of the appearance and shedding of the different deciduous teeth, the appearance of the permanent series, and other changes of contour of the head from the young to the fully adult form of *Diceratherium cooki*.

1. A skull of a young *Diceratherium*, No. 1848 (See Pl. LXV, Figs. 1, 2, 4) which belongs to the original series from which the type of *D. cooki* was selected, is especially complete and furnishes an excellent opportunity for study. In viewing this skull from above, the most noticeable characters are the following: brain-case proportionally broad; occiput short; frontals broad; horn-cores little developed, and nasals gradually pointed, more like that of adult females. Back of the horn-cores on the lateral margin of the nasals there is also less constriction in skulls of young individuals and adult females than is the case in males. The supra-orbital ridges are so varied that one cannot attach great importance to them, though it would appear that in female skulls they are generally less prominently developed and in their backward progression to the occiput they possibly have a tendency to be further separated from the median line. On either a direct side view or a palatal view of the young skull the most noticeable feature is the great backward extent of the alveolar border of the maxillary. The alveole for M^3 is seen to be nearly opposite the pterygoid, while in fully adult forms this tooth is well in advance of this region. In very young individuals, the base and the supra-occipital of the skull are often slipped off at the sutures, not an unusual feature of the mammalia. In the skull here described, the base is lost, but the supra-occipital is in position.

Buried deep in the small round alveolus, the point of the upper permanent incisor is found. Judging from the size of the alveole, the deciduous tooth was rather small and had a root of more rounded outline than the permanent one, and the crown was perhaps also of an entirely different shape. There is no canine present and, if there were a deciduous canine in this individual, it dropped out early and the alveole was closed, there being in this region a small groove which extends for a short distance back of the maxillary-premaxillary suture. If there was a deciduous first premolar in the Diceratheres, it was possibly shed very early in life.[30] P^1 is somewhat worn, but not enough to lose the characters of the grinding face. (See Pl. LXV, Fig. 2.) The ectoloph is, as usual, well developed, the protoloph is less prominent than the metaloph, which gives to the tooth the characteristic triangular outline. The post-fossette is sometimes constricted in such a manner as to form an isolated fossette on the metaloph on further wear, while the main post-fossette continues to the posterior edge of the tooth. This fossette is not always present. $D.P^2$ is considerably worn, but the detailed structure is yet easily made out. The tooth is longer than the permanent tooth, the ectoloph is heavy, the protoloph is well developed internally as is also the metaloph. The crista is enormously developed, extending on an even internal line with the proto- and metalophs. In a young or unworn tooth this ridge is often constricted so as to form an internal tubercle, which on further wear unites with the true crista. In the young of the John Day forms both the crista and this internal tubercle are less developed and apparently entirely separated, judging from the material in the American Museum. This is admirably illustrated on Pl. LXV Fig. 3. The crochet of $D.P^2$ in *D. cooki* is quite distinct though much less developed than the crista, and the cingulum is well developed on the internal face of the tooth. In excavating the maxillary above $D.P^2$ it is seen that P^2 is quite well advanced. See Pl. LXV, Fig. 1. $D.P^3$ is well worn. The median valley is open, but the crochet is evidently united with the ectoloph, while the post-fosette is isolated by wear of the tooth. There is a small tubercle on the internal cingulum in the median valley. $D.P^4$ has the well developed crochet still separated from the ectoloph, but the crista is rather poorly developed or wanting. The median valley is open and, as in the preceding tooth, there is a small tubercle on the cingulum at the exit of the valley. The post-fossette is broad and open. M^1 is fully erupted and has already received some wear. The ectoloph is yet quite thin, but in excavating

[30] If P^1 in *Diceratherium* did not succeed a milk-tooth in extremely early stages of the animal, this tooth may be regarded as a persistent milk-tooth which would agree with the studies of Huxley ("Anatomy of Vertebrate Animals," p. 362); Lydekker ("Notes on the Dentition of Rhinoceroses," Jour. Asiatic Society of Bengal, Vol. 49, 1880, pp. 135–6).

the median and prefossettes, the walls of the internal face of the ectoloph and the external face of the crochet are rapidly slanting toward one another, so that on extreme wear the tooth would have the usual appearance seen in old individuals of this species. The post-fossette is deep and broad. The cingulum is less developed internally than on the milk premolars. M^2 is just appearing in its alveolus and M^3 is entirely buried in the maxillary.

2. In a somewhat younger individual (No. 2476) it is observed that the roots of $D.P^2$ are longer and heavier and in excavating the maxillary, P^2 is found in an extremely early stage of formation (often no evidence of it is found). M^1 in this individual is just cutting through the alveolar border, while that in the specimen described above has received slight wear. There can be only a comparatively small difference in age of these two individuals, and it thus appears that the permanent teeth developed extremely rapidly after they began to show the form of tooth in the maxillary bone. This rapid formation and development of the permanent dentition in *Diceratherium* should not be regarded as out of the ordinary when comparison is made with the shedding of the deciduous and the appearance of the permanent teeth in man and other mammals.

3. In the collection of the Carnegie Museum are two left rami (Nos. 1820 and 1821) representing very young animals, most probably fœtal. The total length of the rami of each of these young specimens is approximately 180 mm., while the depth in the middle antero-posterior region is 28 mm. The most characteristic features are as follows:

The lunate-shaped outline of the ramus due to the greatly downward curved under border of the jaw in the fore-and-aft direction, the close proximity of the cheek-teeth to the canine and the incisors, due to the absence of a diastema on the alveolar border of the jaw, the very slight constriction in front of the cheek-teeth and back of the incisors which is so very pronounced in adult and even in quite young specimens, the small transverse diameter of the symphysis, and the deep groove on the external face of the jaw extending from the symphysis about 20 mm. back in a parallel line with the long axis of the ramus. The glenoid condyle is not present in either one of the rami; the coronoid process on the other hand is present in No. 1820. The latter is rather low, and terminates in an attenuated process.

The second deciduous incisor is in place, while the alveolus for the first is empty. The lateral incisor is not present and a small opening external to $D.I_2$ of this individual may or may not have contained this tooth. The small alveolus for the canine is immediately in front of that for $D.P_1$; the latter is a round opening

of considerable size. The two succeeding round openings are for the roots of D.P_2. Back of this point the two succeeding cheek-teeth are partly erupted. (See Pl. LXVI, Figs. 3, 8 and 9.) The general pattern of these teeth is quite similar to that of the permanent set, indeed it is not easy to distinguish one set from the other. Portions of a fifth cheek-tooth (M_1) lie buried deep in the jaw behind the two just described.

4. Two pairs of lower jaws (Nos. 2476, 2477) have been selected from the collection to represent the next stage of evolution in the development of the ramus, No. 2476 being represented on Pl. LXVI, Fig. 7. The total length of jaws Nos. 2476, 2477 is 250 and 270 mm. and their depth is 36 and 40 mm. respectively. At this stage the jaw is easily recognizable, as all the characteristic generic features are present. The jaw is less lunate-shaped, the characteristic diastema in front of the cheek-teeth is quite well developed, including the constriction of the alveolar border, which in the younger stage is represented only by the deep groove on the external face of the ramus referred to above. In this stage of development the chin is broader, due to the lodgment of the already well-advanced lateral incisor. The temporal fossa is well developed, as are the condyle and the coronoid process.

The median incisors are just through the alveolar border and present the same small and conical-shaped crowns met with in older forms. These teeth are succeeded by a short diastema before the alveoli of D.I_2 is reached. The latter is situated somewhat posterior to I_1 and I_3 in the alveolar border and is thus placed in an irregular position. In the specimens of the Carnegie Museum under observation there is sometimes found a delicate septum separating the second and third incisors. This bony bridge is often broken. D.I_3 is frequently found in position as is the case in the specimen here described, see Pl. LXVI, Fig. 7. This tooth has a long root, quite robust, on which sits a small enamel-covered crown very little larger in circumference than the root itself. The two lateral incisors are succeeded by a diastema; the alveolar border here forms a heavy rounded edge with a noticeable swelling on the external face. This swelling of the incisive alveolar border is due entirely to the rapid development of the cutting incisor of the second set of teeth which is yet buried underneath the deciduous dentition. The deciduous canine is found in many individuals. This is a small tooth with a conical enamel-covered crown and a rather short root. The canine is quite generally found in a procumbent position, isolated by diastemata in front and behind, and drops out very early. The diastema back of the canine constitute a long and sharp border which has first a slight inward curvature and then suddenly takes an outward direction to meet the cheek dentition. The first deciduous cheek-tooth is rather

small, simple-crowned, receives comparatively little wear, and is closely crowded to the anterior faceof the succeeding tooth. D.P_2 is proportionally longer and narrower than P_2. The configuration of the crown is otherwise quite similar in the two. D.P_3 has by far the greatest wear and is, if one may judge by the degree of wear, the first cheek-tooth to appear in the young. D.P_4 is less worn and cuts the alveolar border simultaneously with or perhaps a little sooner than D.P_2. Back of D.P_4 are seen the points of the crown of M_1 and back of the last-mentioned tooth the alveolar border is deeply marked to indicate the position of M_2 which is still entirely buried in the jaw.

5. The next stage of development in the succession of teeth from the deciduous to the permanent series is interesting. Three individuals have been selected which fairly well cover the main points in individual variation and irregularities of development. Of these three individuals No. 1923*a* might be considered as the most normal and will be first discussed. The small median incisor occupies the usual position, while the permanent lateral incisor has broken through the alveolar border (Pl. LXVI, Fig. 5), uniting the alveoli for D.I_2 and D.I_3 into a large transversely oblongate fissure for receiving the cutting and procumbent incisor.[31] In this individual the alveolus for the canine of the right ramus is present, though very small, while in the left there is no trace of an alveolus for the canine. D.P_1 is in place while D.P_2 has been shed and the crown of P_2 appears through the alveolar border. D.P_3 is still in place but P_3 is well advanced and the deciduous tooth was almost ready to drop off before the death of this individual. D.P_4 is apparently quite solid in the jaw and still served well for masticating purposes. M_1 has already received considerable wear, while M_2 is almost entirely erupted. M_3 is quite undeveloped and is buried deep in the jaw.

6. The next specimen to be considered is No. 1841, a pair of lower jaws. This specimen presents some irregularities worthy of note. From the illustration (Pl. LXVI, Fig. 6) it is seen that the permanent lateral incisors of this specimen are retarded, *i.e.*, they have not yet appeared above the surface of the alveolar border; the alveoli for the canines are quite large. D.P_1 is still in place, but contrary to the specimen just described both D.P_2 and D.P_3 have disappeared and P_2 and P_3 have already received some wear, D.P_4 is solidly inserted in the jaw, M_1 has been in use for some time and is considerably worn as in No. 1923*a*, while M_2 has received slight wear on the anterior portion. M_3 on the other hand is apparently no further developed than in the specimen previously described.

[31] In the judgment of the writer this incisor is probably I_2 while I_3 and the canine of the Diceratheres are atrophied.

7. In No. 1854 it is seen that the lateral incisor is no further advanced than in No. 1841 just described. The alveole or deep groove[32] for the deciduous canine is still quite prominent while D.P_1 is shed and all traces of its alveole entirely obliterated. P_2 and P_3 have received slightly more wear than those teeth in the previous specimen described, but D.P_4 is still well rooted in the alveolar border. M_1 is quite well worn and the anterior part of M_2 is also more worn than that in No. 1841. The deep fissure back of M_2 indicates the position of M_3. The latter is very little further developed than in the two preceding specimens and is yet buried in the angle of the jaw. The three lower jaws just described are of approximately the same age as the skull No. 1848, referred to in the opening paragraph of this discussion.

In connection with the probable manner in which the upper and lower incisors of *Diceratherium*[33] developed in size, and modified into the shape in which we find them, it is interesting to return to the fœtal specimens Nos. 1820 and 1821 just described (page 452). We have already found that the deciduous dentition of these specimens forms practically a close series, without the constricted and thin areas of the alveolar border between the cheek-teeth and the incisors of older animals, the alveolus for the canine is deep though small; in excavating the chin, the continuation of the dental canal is found, but the germ for the permanent incisor had not yet started, hence the small transverse diameter of the chin.

In the next stage represented by Nos. 2476 and 2477, the specimens are of quite young animals. We observe here a sudden change. It is likely that the characters so prominently developed in this young animal had already been well advanced during the latter part of the intra-uterine stage. At all events the jaw was still in a very plastic condition in order to have transformed so quickly between the two stages represented in the illustrations (see Pl. LXVI, Figs. 7 and 9). In the specimens of this second stage we find a broad and heavy chin in order to support the heavy and long-rooted permanent incisor. The alveolus for the canine, which we originally found quite deep and placed close to the cheek-teeth, is now shifted well forward and is transformed into a shallow groove, which in

[32] In more matured individuals, the fissure in the alveolar border which lodged the canine cannot be regarded as a true alveolus.

[33] Not only *Diceratherium* but the Rhinocerata in general (such forms as the Amynodonts excepted) undoubtedly developed the cutting incisors along the same general line.

The result of the present study is contrary to the statement by Professor Marsh (Amer. Jour. Sci., Vol. XIV, 1877, p. 251). It may be said here that the presence of the canines in the Amynodonts does not prove "that the large lower teeth, usually regarded as incisors in *Aceratherium* and many other members of the Rhinoceros family, are really canines."

the majority of cases is empty, the small canine lodged therein having dropped out, while back of the canine we find a long diastema which is very much constricted forming externally a deep and rather broad groove for the lodgment of the inferior labial muscles.

Let us suppose that the foetal specimens referred to have the jaws more or less like those of the early Tertiary forms. We must in any event expect that the early progenitors of the family had, first a complete dental series, *i.e.*, $\frac{3}{3} \cdot \frac{1}{1} \cdot \frac{4}{4} \cdot \frac{3}{3}$ (abundantly proven by the genus *Trigonias* of the lower Oligocene); and secondly quite likely the absence of a diastema back of the incisors.[34] It follows that advancing influences effected gradual changes of the bony structure simultaneously with that of the teeth. If we have, for instance, a set of lower incisors of subequal size and a normal canine in its natural position (we actually do find evidence of a canine in young Diceratheres), we should expect the upper incisors to meet the lower. When the atrophied and hypertrophied changes took place, which transformed the original sub-equal teeth to those which obtained in later forms, *it was not the lower canine, but* I_2, *which received the constant impact from the upper median tooth.* The diastemata between the incisors, canine, and cheek-teeth was most likely an early development of the group. The modification of the cutting incisor was cotemporaneous with the reduction of I_1 the atrophy of I_3, the broadening of the chin, and the constriction of the ramus in the region of the canine which, in turn probably, caused the reduction and final disappearance of the latter tooth. After the present study of the *Diceratherinæ*, I cannot accept the designation given to this tooth, as "canine," by some authors, Professors Marsh, Cope, and Gaudry having been the first to promulgate this view.

Since the preceding paragraphs were submitted for publication, Professor W. B. Scott of Princeton University has published his splendid work on the "History of Land Mammals in the Western Hemisphere." On consulting the history of the Rhinocerotidæ in Scott's volume, pp. 326–340, it is very evident that he does not regard the large cutting incisor of the lower jaw in the early Rhinoceroses as a canine. In fact since the genus *Trigonias* from the Lower Oligocene of America was established by Mr. Lucas [35] and more completely described by Mr. Hatcher[36] the morphology of the incisors and canines of the Rhinocerotidæ rests on a firmer foundation.

[34] Even in *Colonoceras agrestis* Marsh, a genus which might be regarded as possibly near the ancestral line of the Diceratheres, there is a well-established diastema back of the superior canines.

[35] Proc. National Museum, Vol. XXIII, 1900, pp. 221–223.

[36] Ann. Carnegie Museum, Vol. I, 1901, pp. 135–144.

EXPLANATION OF PLATE LVII.

Fig. 1. *Diceratherium armatum*, type. Side view of skull. Peabody Museum, No. 10003.

Fig. 2. *Diceratherium armatum*, type. Palatal view of same specimen as Fig. 1.

All figures about $\frac{3}{8}$ natural size.

1

2

Diceratherium armatum MARSH.

EXPLANATION OF PLATE LVIII.

FIG. 1. *Diceratherium nanum*, (Marsh) type. Peabody Museum of Natural History, No. 10004. Front of skull from the side.

FIG. 2. *Diceratherium nanum*, type. Front of jaws from the side.

FIG. 3. *Diceratherium nanum*, type. Alveolar border and dentition.

FIG. 4. *Diceratherium cooki*. Carnegie Museum, No. 1555.

All figures ½ natural size.

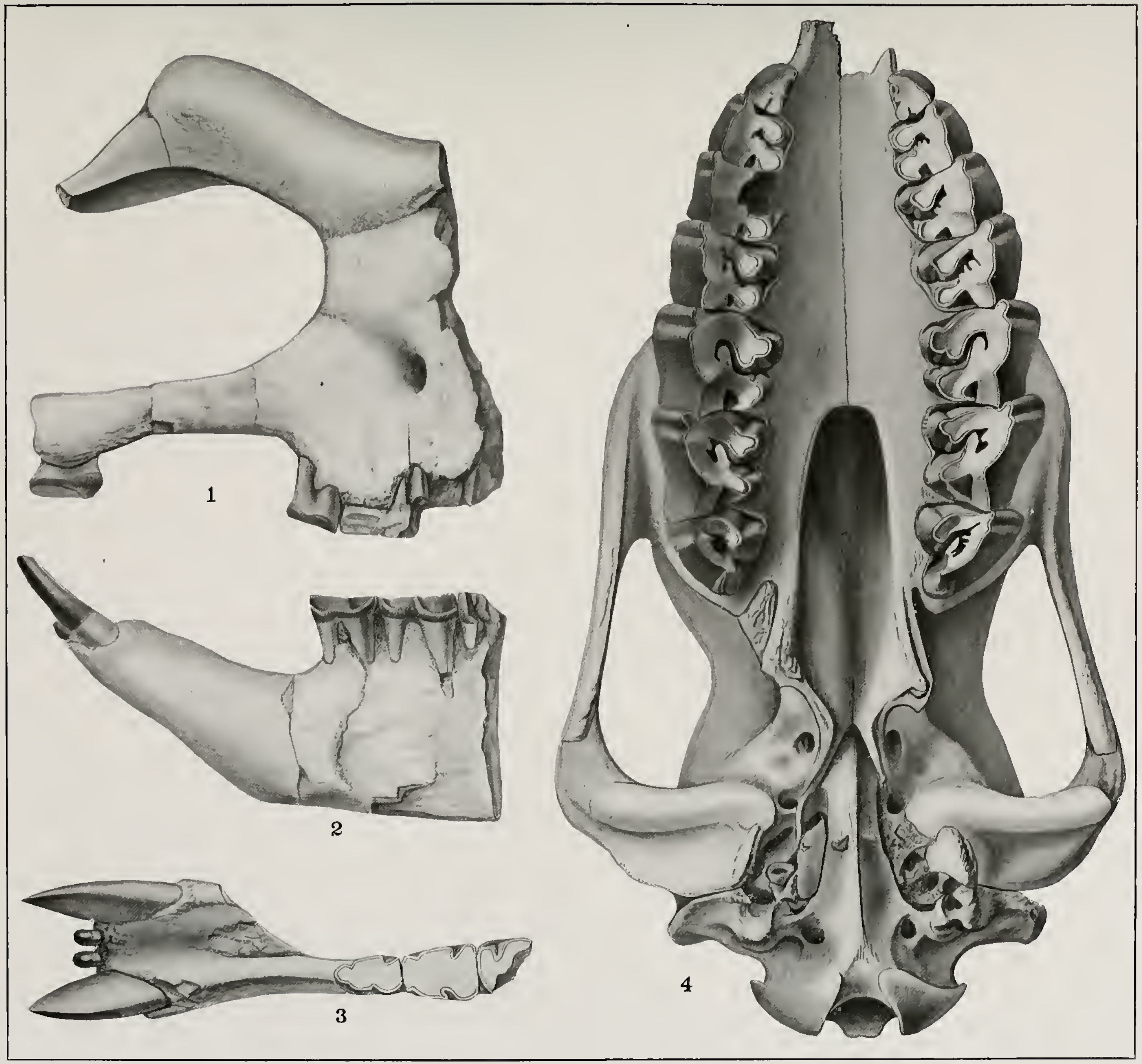


FIG. 1–3, TYPE OF *D. nanum* MARSH; FIG. 4, *D. cooki* PETERSON.

EXPLANATION OF PLATE LIX.

FIG. 1. *Diceratherium gregorii,* type. Side view of skull. American Museum of Natural History, No. 12933.

FIG. 2. *Diceratherium gregorii,* type. Palatal view of the same skull.

All figures $\frac{1}{3}$ natural size.

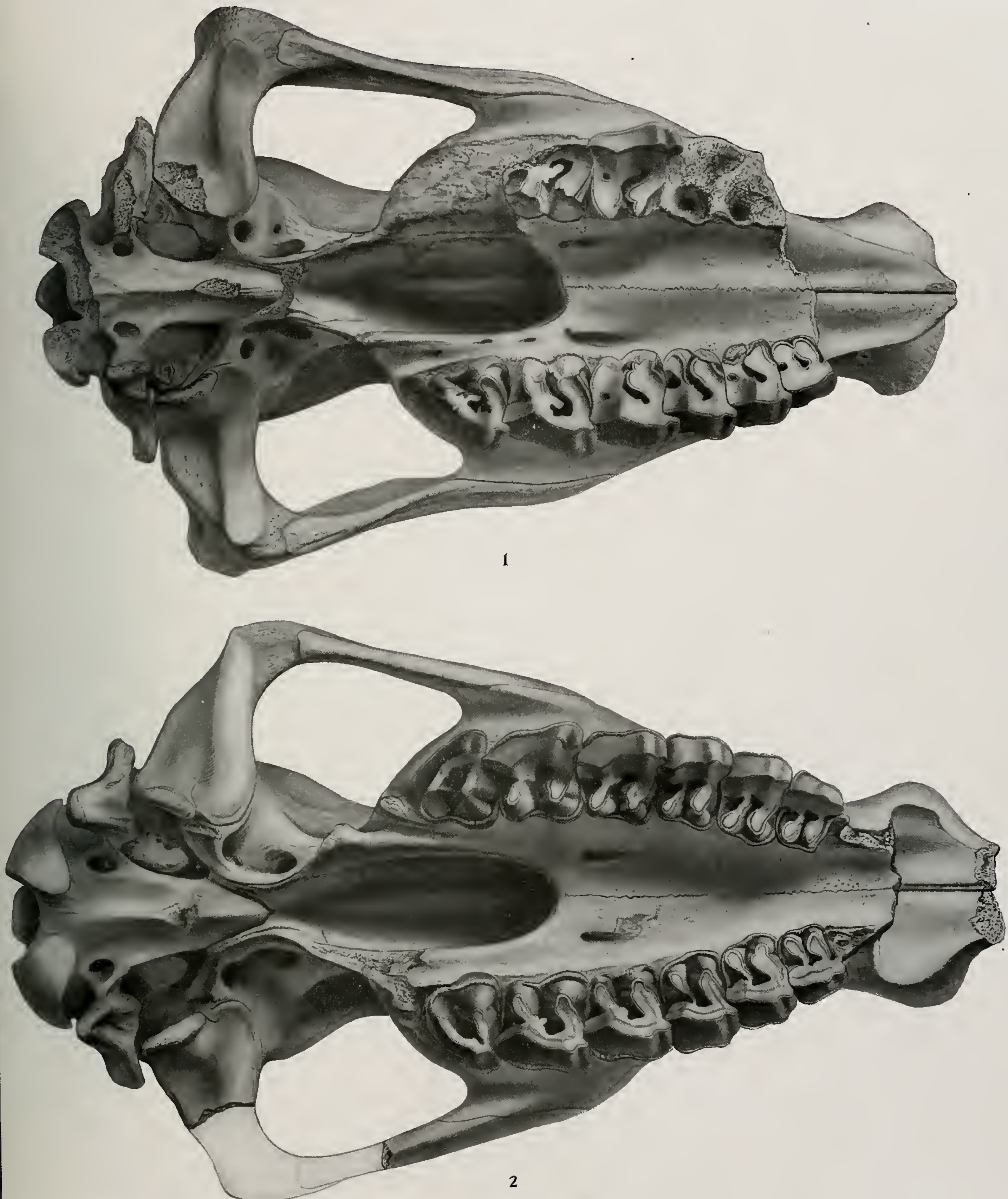
D. gregorii PETERSON.

EXPLANATION OF PLATE LX.

Fig. 1. *Diceratherium cooki* type. Carnegie Museum, No. 1572.

Fig. 2. *Diceratherium niobrarense* type. Carnegie Museum, No. 1271.

Fig. 1, $\frac{1}{2}$ natural size; Fig. 2, $\frac{4}{9}$ natural size.



D. cooki PETERSON AND *D. niobrarense* PETERSON.

EXPLANATION OF PLATE LXI.

FIG. 1. *Diceratherium cooki*, type. Carnegie Museum, No. 1572.

FIG. 2. *Diceratherium niobrarense*, type. Carnegie Museum, No. 1271.

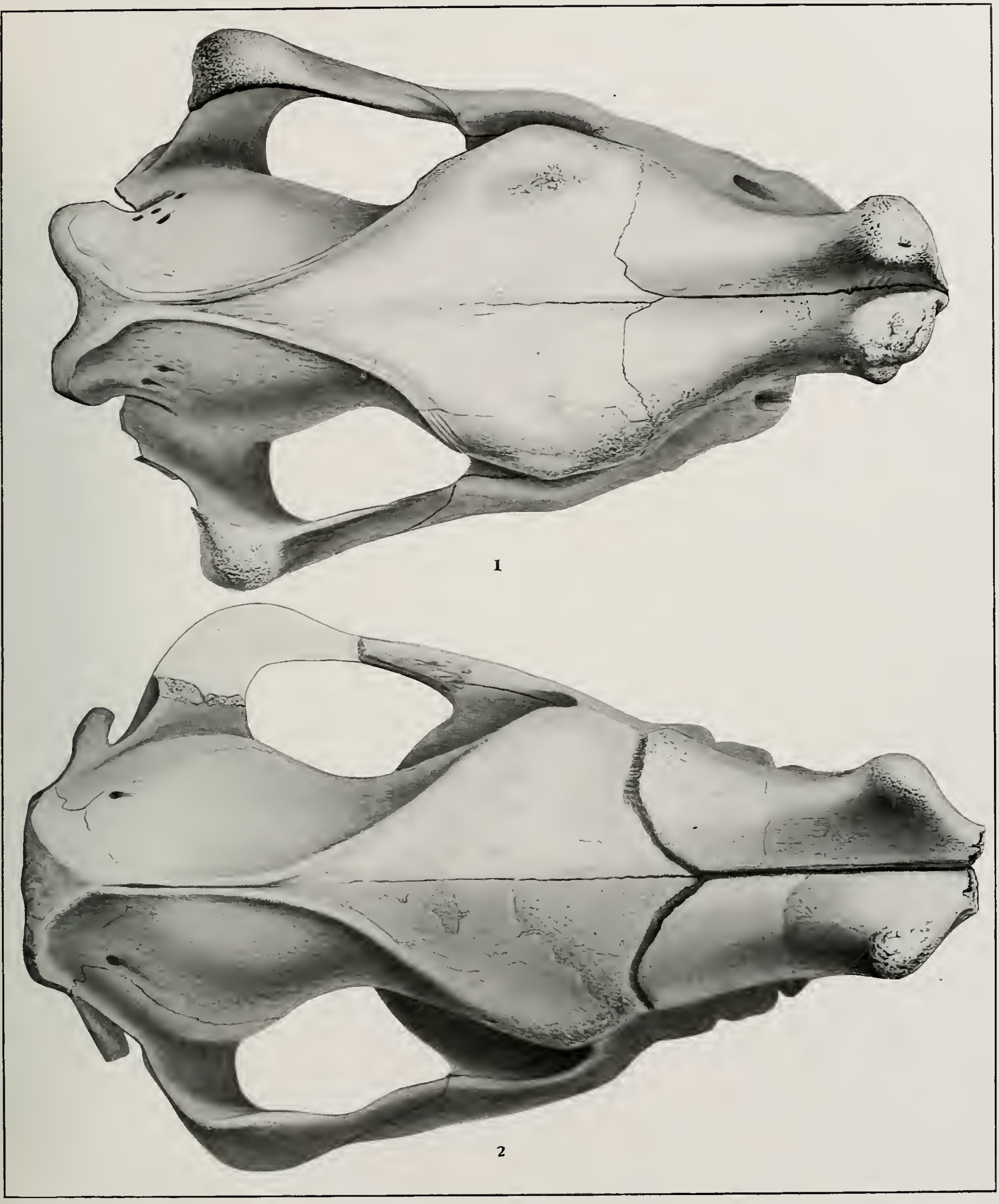
Fig. 1, $\frac{1}{2}$ natural size; Fig. 2, $\frac{4}{9}$ natural size.

D. cooki PETERSON AND *D. niobrarense* PETERSON.

EXPLANATION OF PLATE LXII.

FIG. 1. *Diceratherium cooki*, type. Carnegie Museum, No. 1572.
FIG. 2. *Diceratherium niobrarense*, type. Carnegie Museum, No. 1271.

Fig. 1, $\frac{1}{2}$ natural size; Fig. 2, $\frac{4}{9}$ natural size.



D. cooki PETERSON AND *D. niobrarense* PETERSON.

EXPLANATION OF PLATE LXIII.

Fig. 1. *Diceratherium cooki*, ulnar view of manus, Carnegie Museum, No. 2473.

Fig. 2. *Diceratherium cooki*, palmar view of manus, Carnegie Museum, No. 2473.

Fig. 3. *Diceratherium cooki*, radial view of manus, Carnegie Museum, No. 2473.

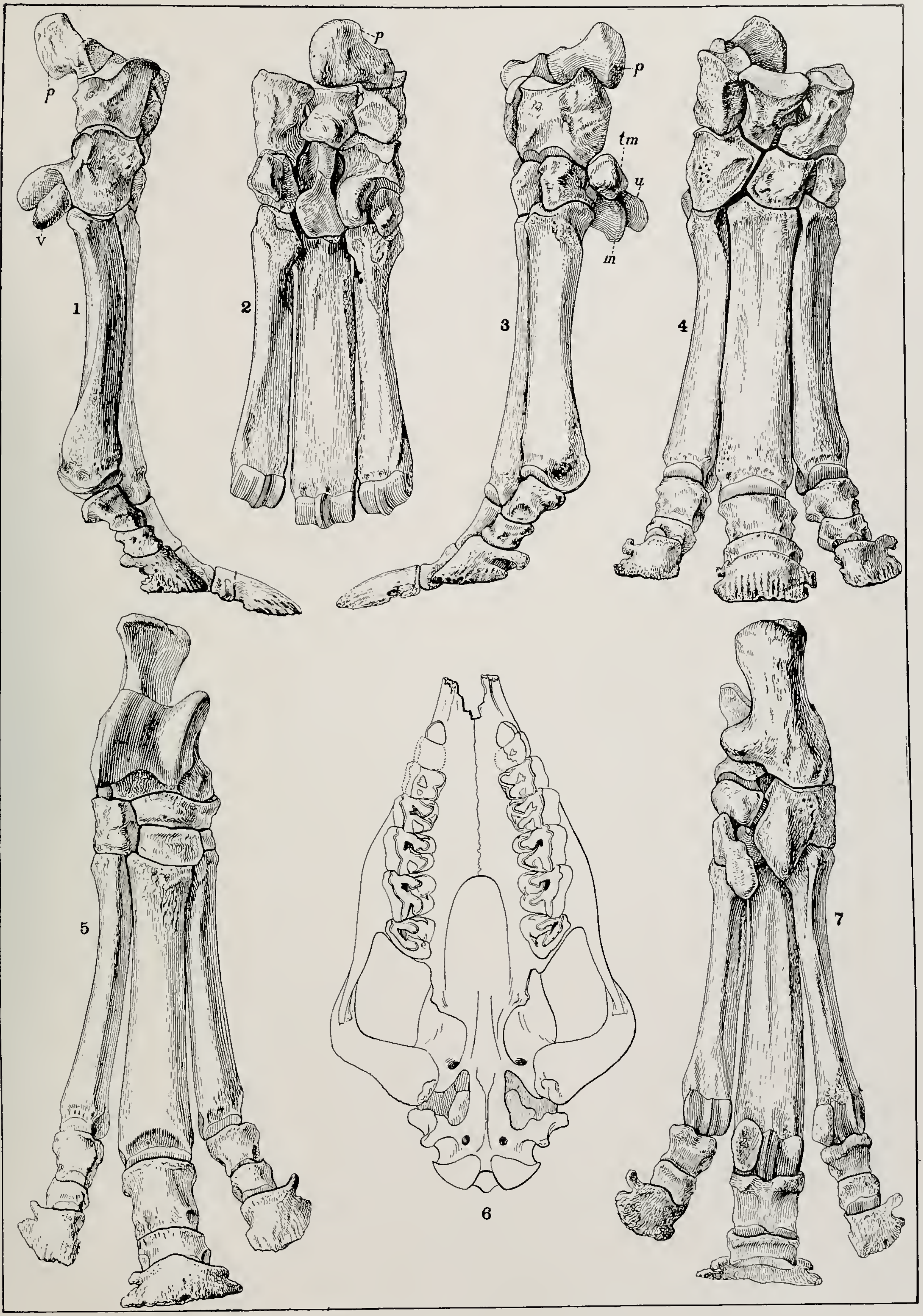
Fig. 4. *Diceratherium cooki*, dorsal view of manus, Carnegie Museum, No. 2473.

Fig. 5. *Diceratherium cooki*, dorsal view of pes, Carnegie Museum, No. 1888.

Fig. 6. *Diceratherium annectens* hypotype, American Museum Natural History, No. 7324, Cope Coll.

Fig. 7. *Diceratherium cooki*, plantar view of pes, Carnegie Museum, No. 1888.

All figures ½ natural size except Fig. 6, which is ¼ natural size.



D. cooki PETERSON AND *D. annectens* (MARSH).

EXPLANATION OF PLATE LXIV.

Diceratherium cooki.

Carnegie Museum, No. 1888.

- Fig. 1. Calcaneum, dorsal view.
- Fig. 2. Calcaneum, distal view.
- Fig. 3. Calcaneum, plantar view.
- Fig. 4. Calcaneum, tibial view.
- Fig. 5. Calcaneum, fibular view.
- Fig. 6. Astragalus, tibial view.
- Fig. 7. Ectocuneiform, proximal view.
- Fig. 8. Ectocuneiform, distal view.
- Fig. 9. Ectocuneiform, tibial view.
- Fig. 10. Astragalus, fibular view.
- Fig. 11. Astragalus, plantar view.
- Fig. 12. Astragalus, dorsal view.
- Fig. 13. Cuboid, proximal view.
- Fig. 14. Cuboid, tibial view.
- Fig. 15. Entocuneiform, fibular view.
- Fig. 16. Entocuneiform, distal view.
- Fig. 17. Navicular, distal view.
- Fig. 18. Navicular, posterior view.
- Fig. 19. Navicular, fibular view.
- Fig. 20. Navicular, proximal view.
- Fig. 21. Cuboid, distal view.
- Fig. 22. Mesocuneiform, distal view.
- Fig. 23. Mesocuneiform, fibular view.
- Fig. 24. Mesocuneiform, tibial view.
- Fig. 25. Mesocuneiform, proximal view.
- Fig. 26. Metatarsal III, dorsal view.
- Fig. 27. Metatarsal III, fibular view.
- Fig. 28. Metatarsal II, fibular view.
- Fig. 29. Metatarsal II, tibial view.
- Fig. 30. Metatarsal IV, tibial view.
- Fig. 31. Metatarsal III, tibial view.
- Fig. 32. Metatarsal III, plantar view.

Carnegie Museum, No. 2453.

- Fig. 33. Scaphoid, proximal view.
- Fig. 34. Scaphoid, distal view.
- Fig. 35. Scaphoid, ulnar view.

Carnegie Museum, No. 2453.

- Fig. 36. Lunar, proximal view.
- Fig. 37. Lunar, radial view.
- Fig. 38. Lunar, distal view.
- Fig. 39. Lunar, ulnar view.
- Fig. 40. Cuneiform, radial view.
- Fig. 41. Cuneiform, distal view.
- Fig. 42. Cuneiform, ulnar view.

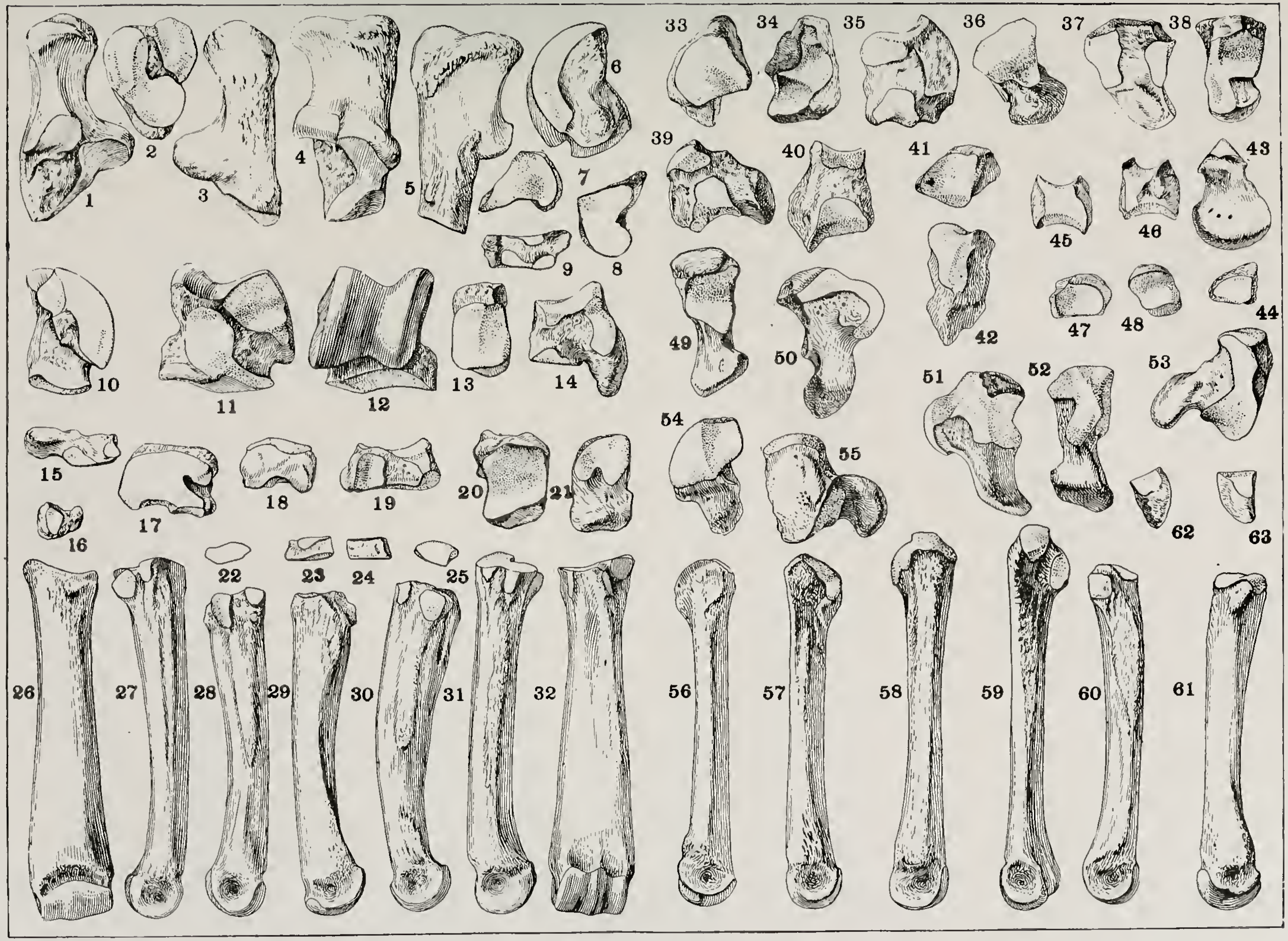
Carnegie Museum, No. 1853.

- Fig. 43. Pisiform, radial view.
- Fig. 44. Trapezium, ulnar view.
- Fig. 45. Trapezoid, radial view.

Carnegie Museum, No. 2453.

- Fig. 46. Trapezoid, ulnar view.
- Fig. 47. Trapezoid, distal view.
- Fig. 48. Trapezoid, proximal view.
- Fig. 49. Magnum, distal view.
- Fig. 50. Magnum, ulnar view.
- Fig. 51. Magnum, radial view.
- Fig. 52. Magnum, proximal view.
- Fig. 53. Unciform, radial view
- Fig. 54. Unciform, proximal view.
- Fig. 55. Unciform, ulnar view.
- Fig. 56. Metacarpal II, radial view.
- Fig. 57. Metacarpal II, ulnar view.
- Fig. 58. Metacarpal III, radial view.
- Fig. 59. Metacarpal III, ulnar view.
- Fig. 60. Metacarpal IV, radial view.
- Fig. 61. Metacarpal IV, ulnar view.
- Fig. 62. Metacarpal V, radial view.
- Fig. 63. Metacarpal V, palmar view.

All figures are $\frac{1}{2}$ natural size.



D. cooki PETERSON.

EXPLANATION OF PLATE LXV.

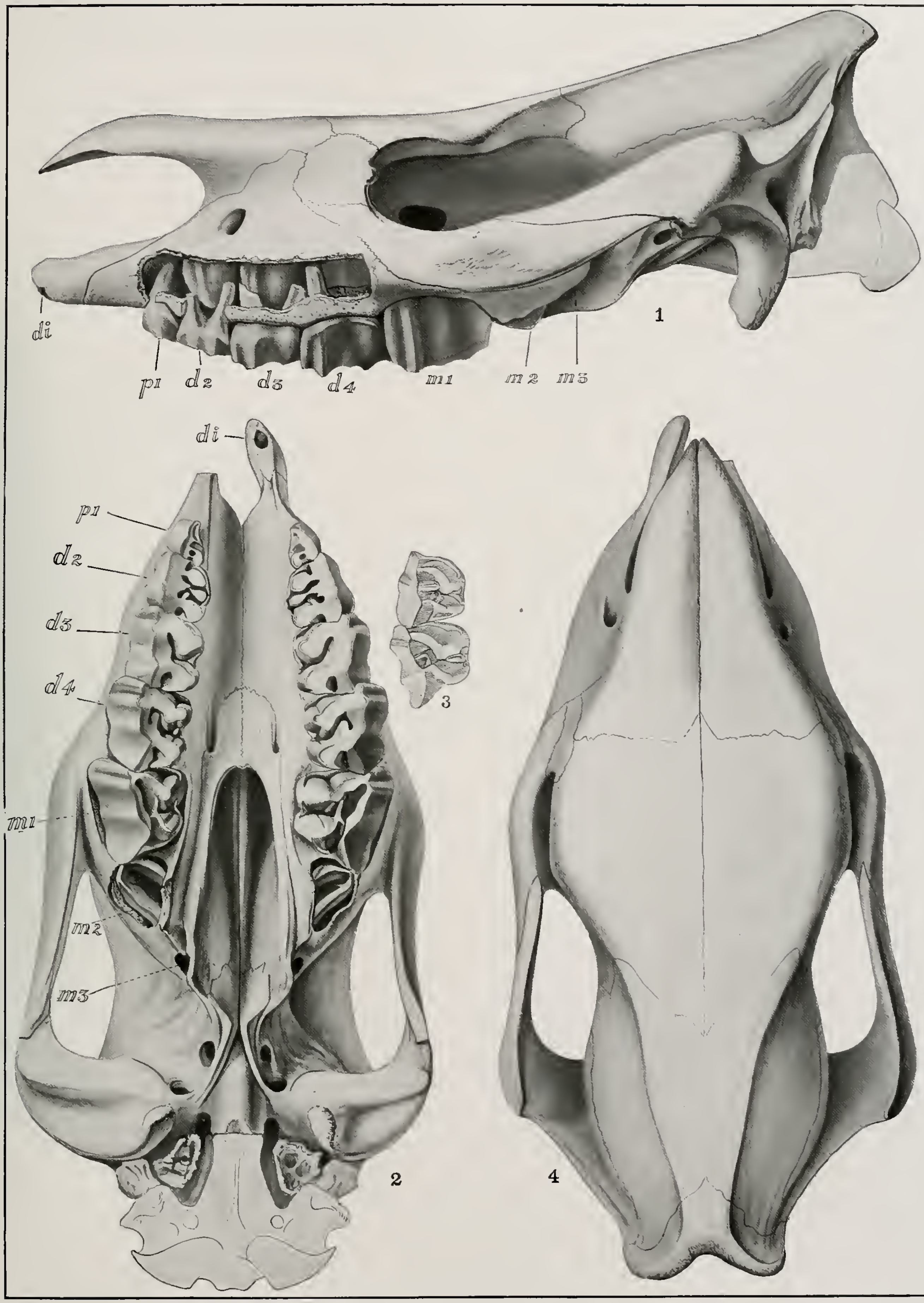
Fig. 1. *Diceratherium cooki,* young male, side view of skull. Carnegie Museum, No. 1848.

Fig. 2. *Diceratherium cooki,* Palatal view same as Fig. 1.

Fig. 3. *Diceratherium? annectens,* deciduous upper teeth, American Museum collection.

Fig. 4. *Diceratherium cooki,* top view of skull, same as Figs. 1 and 2.

All figures $\frac{1}{2}$ natural size.



D. cooki PETERSON AND *D. annectens* (MARSH).

EXPLANATION OF PLATE LXVI.

Fig. 1. *Diceratherium annectens,* hypotype, Side view of skull, American Museum, No. 7324, Cope Coll.

Fig. 2. *Diceratherium cooki,* upper contour of lower jaws and crown view of dentition. Carnegie Museum, No. 2499.

Fig. 3. *Diceratherium cooki,* outer view of mandible in very young stage of development. Carnegie Museum, No. 1820.

Fig. 4. *Diceratherium cooki,* outer view of mandible of fully adult male. Carnegie Museum, No. 2499.

Fig. 5. *Diceratherium cooki,* alveolar border of lower jaw and crown view of dentition. Carnegie Museum, No. 1923*a*.

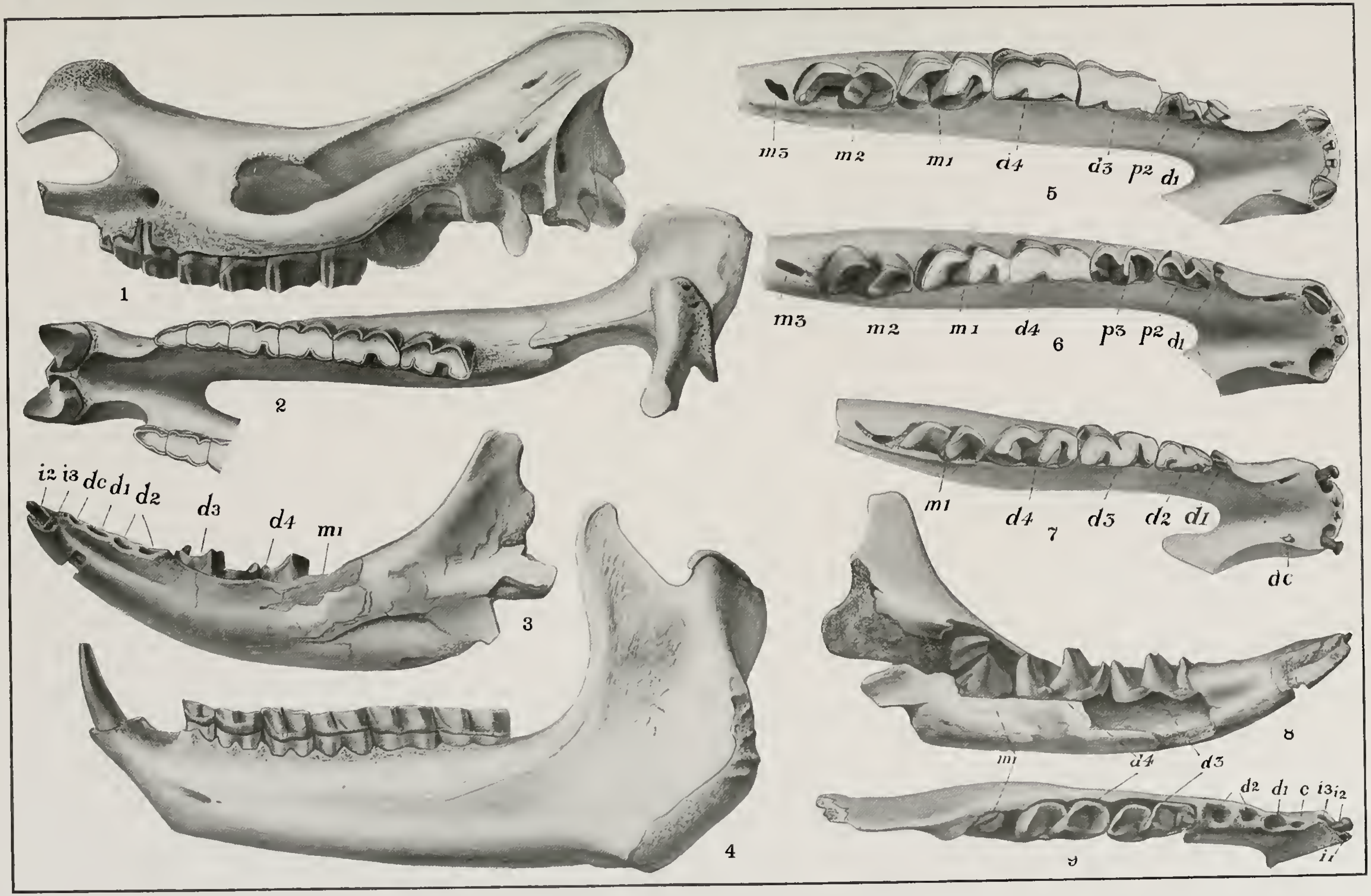
Fig. 6. *Diceratherium cooki,* alveolar border of lower jaw and crown view of dentition. Carnegie Museum, No. 1841.

Fig. 7. *Diceratherium cooki,* alveolar border and crown view of dentition. Carnegie Museum, No. 2476.

Fig. 8. *Diceratherium cooki,* inner view of mandible, very young stage of development, Carnegie Museum, No. 1820.

Fig. 9. *Diceratherium cooki,* upper contour of lower jaw and crown view of dentition, same as Nos. 3 and 8.

Fig. 1 is $\frac{1}{4}$ natural size; Figs. 2 and 4 are $\frac{1}{3}$ natural size; Figs. 3, 5, 6, 7, 8, and 9 are $\frac{1}{2}$ natural size.



D. cooki PETERSON AND *D. annectens* (MARSH).